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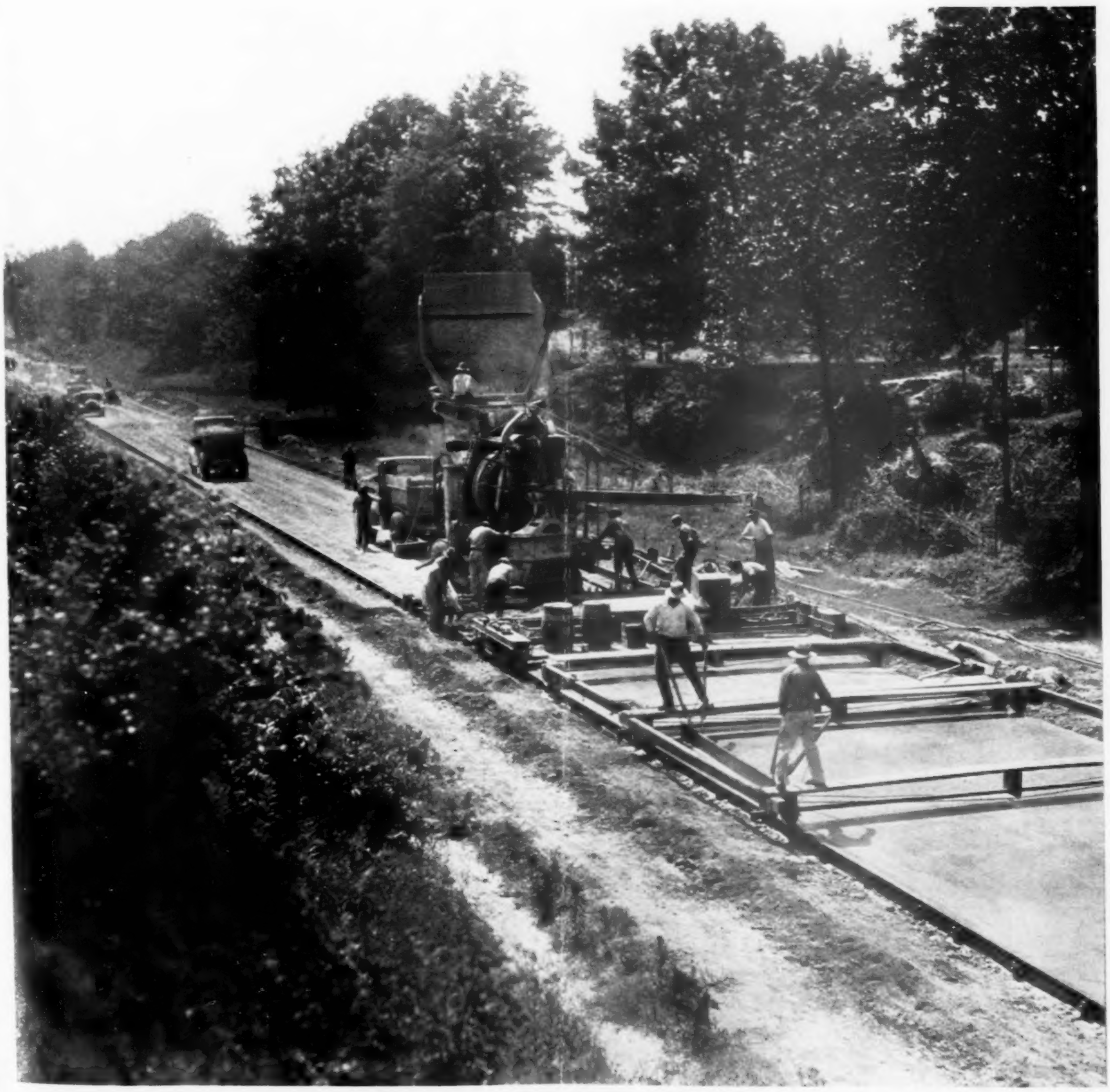

LAYING A CONCRETE ROAD SURFACE

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BUREAU OF PUBLIC ROADS

G. P. St. CLAIR, *Editor*

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The reports of research published in this magazine are necessarily qualified by the conditions of the tests from which the data are obtained. Whenever it is deemed possible to do so, generalizations are drawn from the results of the tests; and, unless this is done, the conclusions formulated must be considered as specifically pertinent only to described conditions

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SOME ASPECTS OF PORTLAND CEMENT CONCRETE PAVEMENT CONSTRUCTION

BY THE DIVISION OF MANAGEMENT, UNITED STATES BUREAU OF PUBLIC ROADS

Reported by WILLIAM A. BLANCHETTE, Highway Engineer

STUDIES of production in highway construction have been made by the Division of Management of the Bureau of Public Roads from 1923 to the present year. These studies have included grading and surfacing of nearly all types of highways in practically all sections of the United States.

The number and mileages of concrete roads constructed and the magnitude of the funds invested in them justify considerable study. During 1930 approximately 10,000 miles of portland cement concrete pavements were laid on rural highways of which 8,500 miles were on State systems. In 1930 the average cost per mile of a 20-foot concrete surface, exclusive of engineering, drainage structures, and rough grading, was about $22,500, a total cost of approximately $225,000,000 for the year. A greater efficiency in such large-scale production will result in correspondingly lessened costs to the public.

In the studies here reported, data were collected relative to personnel, equipment, and efficiency of operation. The causes of efficiency on certain projects were analyzed. Between 1923 and 1929 numerous changes were made in types and sizes of equipment used and in methods of construction. From 1929 to June 1934 changes have not been so extensive. This discussion is based upon investigations made during the latter period.

EFFICIENCY IN CONSTRUCTION GREATLY IMPROVED IN RECENT YEARS

The following observations and conclusions are a result of these studies:

1. The equipment used in concrete surfacing is reasonably well standardized as to type, capacity, and number of units.
2. The number of men employed on a concrete paving job varies between wide limits. The average personnel, exclusive of truck drivers, on the 34 projects analyzed numbered 68 men with a minimum of 42 and a maximum of 98.
3. The combination of personnel and equipment on concrete paving projects observed was usually adequate to the handling of the maximum possible production of the key equipment.
4. There is considerable difference in the over-all efficiency with which different contractors operate the major or key equipment. The average over-all efficiency of operation of key equipment on projects studied in 1929 and 1930 was 78 percent, with a minimum of 47 percent and a maximum of 97 percent. The average efficiency of operation of key equipment on 10 projects studied between 1923 and 1928 was 55 percent, with a minimum of 42 percent and a maximum of 66 percent. There appears to have been an increase in efficiency in recent years.
5. The efficiency of operation of major equipment is a reasonably accurate measure of the efficiency with which the entire paving organization is operated. It is an indication of the type of supervision employed.
6. Unnecessary interference by inspectors tends to lower operating efficiency and to discourage employment of adequate supervision.
7. About 30 percent of the total cost of a concrete pavement is for cement delivered to the project. Twenty-nine percent is for aggregates delivered to the project. Thirty-seven percent of the cost of cement and aggregates delivered is for transportation. The equipment cost is 9 percent and the labor cost is 11 percent of the total cost of a concrete pavement (exclusive of rough grading, etc.) The daily cost for labor and equipment is almost constant regardless of quantity of production. The unit cost for these two items varies almost inversely with the efficiency of operation.
8. The cement factors used on the projects analyzed varied from 1.23 to 2.10 barrels of cement per cubic yard of concrete.
9. The present method of combining the cement, aggregates, and water into concrete does not produce a homogeneous mass in which these ingredients are uniformly distributed throughout the mass.
10. Present methods of placing and finishing the concrete require fairly wet mixtures, resulting in excess water which decreases the potential strength of the concrete.

PERSONNEL AND EQUIPMENT DESCRIBED

The construction of a concrete pavement requires several separate operations. The subgrade must be prepared. The forms must be set in place. Cement, fine and coarse aggregate and water must be delivered to the paver and mixed. The mixed concrete must be deposited on the subgrade, spread, finished, and cured. These major operations are performed on all concrete paving projects.

Minor operations such as the delivery and placing of reinforcing steel, joints, etc., must be performed also. Each operation requires certain pieces of equipment. Table 1 shows the equipment used on 38 concrete paving projects studied during 1929 and 1930. These projects were located in 18 States and represent nearly every section of the United States. The equipment listed in table 1 is typical of equipment used generally in concrete paving. This table shows the average length of haul from the material yard to the paver in miles during the period of the production study.

Trucks were used for hauling batches except on one project where an industrial railway was used. Single-batch trucks were used on 12 projects; 2-batch trucks on 13 projects; 3-batch trucks on 12 projects, and 4-batch trucks on 2 projects on which 2- and 3-batch trucks were also used.

The mixing on all of the projects was done in standard pavers of the 27-E type. A finishing machine was used on all but 5 projects. On these 5 projects, 4 in 1 State and 1 in another, all finishing was done by hand.

Table 2 shows the personnel employed on the 38 projects. On 34 of them the mixing was done by one 27-E paver. On the remaining 4 projects, two 27-E

TABLE 1.—*Summary of equipment used on projects studied in 1929 and 1930*

	Arkansas no. 1	California no. 1	California no. 2	California no. 3	California no. 4	California no. 5	Colorado no. 1	Illinois no. 1	Iowa no. 1	Louisiana no. 1	Louisiana no. 2	Louisiana no. 3	Louisiana no. 4	Maine no. 1	Michigan no. 1	Missouri no. 1	Missouri no. 2	Nebraska no. 1	New Jersey no. 1
GENERAL INFORMATION																			
Length of project, miles	15.4	11.4	8.5	4.4	5.4	5.2	15.6	9.0	8.8	26.8	10.1	6.8	9.5	3.8	9.5	9.8	37.2	14.6	7.7
Width of pavement, feet	18	20	30	30	30	40	18	18	18	20	18	18	18	20	20	20	20	20	20
Average length of haul during study, miles	6.4	2.7	1.6	1.0	10.0	3.6	2.4	3.5	6.4	5.3	4.2	3.5	1.2	2.8	1.6	2.4	2.5	3.3	3.7
FINE GRADING																			
Blade graders, number and length of blade, feet	1-12 1-10	1-12	2-10	1-8	1-8	1-12 1-8	1-6 1-8		1-12	1-12	1-10	1-12	1-4 1-12			1-5 1-12	1-8 1-10	[1]1	1-6
Tractors, number and horsepower	1-30 1-60	1-30 1-60	2-60	1-60	2-30	1-30 1-60			1-60	1-60	1 1-30	1-60	1 1-60			1-60	2-20 1-30 1-60	1-60	1-30
Motor patrols, number and length of blade, feet								1-8	1-10						1-10			1-8	
Scarifiers, number	1	1	1	1	2	2		1	1	1	1	1	1			1	1	1	
Subgraders, number	1	1	1	1	2	2		1	1	1	1	1	1			1	1	1	
Subgrade planers, number	1						1	1	1	1	1	1	1	1	1	1	1	1	
Rollers, number and size, tons	1-10	1-15	1-13	1	1-12	1-10		2	1-5	1-10	1	1-5	1	1-12	1-10	1-3		1-6	1-10
Fresno teams, number	2		1	1	2	2		2		2	1	2	1		1	5	2	3	2
HANDLING FORMS																			
Lineal feet	4,500	8,000	20,000	8,500	16,000	12,000	3,300	3,000	6,800	4,000	4,200	5,000	4,000	4,000	3,000	4,200	3,300	4,500	6,000
Forms, kind	Steel	Steel	Wood	Wood	Wood	Wood	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel
Wagon teams, number	2								2	1	2	1	2		1	1	2	1	
Trucks, number		1	1	1	1	1	1	1						1					1
Mechanical form trenchers, number	1							1				1	1		1	1		1	
HANDLING MATERIALS																			
Cranes, number and capacity, cubic yards	1-1	1-1	1-1¼	1-1	([2])	([2])	1-1	1-1¼	1-1	1-¾	1-¾	1-1	1-1	1-⅝	1-1	1-1	2-¾	1-1	1-¾
Batcher bins, number	1	1	1	1		1	1	3	1	1	1	1	1	1	1	1	1	1	1
Tractors, number																1			
Cement houses, number			1						1		1	1				1	1		1
Pumps, number	1	2	2	1	1	1	2	1	2	1	1	1	1	1	1	1	1	2	1
Pipe:																			
3-inch, lineal feet			40,000		31,000	27,000		5,000										23,760	
2½-inch, lineal feet		26,500					5,280	16,000	21,000	35,000	6,000	16,000	15,000	6,000		26,400	42,000		21,000
2-inch, lineal feet	26,400			23,000			15,840		31,500		11,000				17,000				
Hose:																			
2-inch, lineal feet	200							400	300			200		200	150	200		300	200
1½-inch, lineal feet				225		600				250	300		100				300		
1-inch, lineal feet		300	200		400														
Service trucks, number		1	1	1	2	3	1	1	2	2	1	2	2	3		1	2	1	1
HAULING BATCHES																			
Trucks:																			
4-batch, number					3			([3])											
3-batch, number		7	7	4	17	18								8	11				7
2-batch, number																			
1-batch, number	17						18		34	29	17	13	11			18	35	27	
Turntables		1	1		1						1	1		1		1	1	1	
MIXING																			
Paving mixers (all 27-E), number	1	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1	2	1	1
FINISHING																			
Strike boards, number and length, feet																			
Finishing machines, number and width, feet	1-18	2-10	1-10	2-10	1-20	2-20	1-18	1-18	1-18	1-20	1-18	1-18	1-18	1-10	1-20	1-20	1-20	1-20	1-10
Longitudinal floats, number and length, feet	2-16	1-16	2-16	1-16	2-16	1-20		1-14	1-10	1-8	1-8	1-10	1-10			1-10	1-10	1-14	
Transverse floats, number and length, feet																			
Rollers, number			1																
Belts or flexible floats, number and length, feet		1-16	1-16	1-16	1-16	1-20	1-18	1-18	2-18	2-18	2-18	2-18	2-18	1-10		1-18	1-20	2-20	
Joint machines, number and width, feet						1-20											1-20		
Hand floats, number			2		2	4		1	7	2	2	2	2		2	2	1	2	3
Straight edges, number								1		2	2	2	2					1	
CURING																			
Burlap, length, feet	1,500	2,000	1,700	1,500	1,200	2,000	500	1,500	2,000	1,000	1,000	800	1,000	700	900		1,800	5,280	
Hose, ¾-inch, feet	200	200	200	200	200	600	350	300	1,000	400	300	200	200	200	300			1,450	
Curing spray apparatus, number								[4]1		1			1			1	[4]1		1

[1] Elevating grader. [2] Commercial aggregate plants. [3] All batches hauled by industrial railway. [4] Calcium chloride.

pavers were used either parallel or in tandem. Table 2 shows a wide variation between projects both as to the total number of men employed and the number employed to perform various operations. The major operations are relisted in table 3 which gives, for purposes of comparison, analyses of the numbers of men required for each operation on 34 paving projects using a single paver and those required on 4 projects using 2 pavers each.

The size of the crew necessary for fine grading is affected by several factors: The amount and character of the material to be moved, the amount and kind of equipment used, the efficiency of operation, and the rate at which pavement is being laid. The fine-grading crew varies considerably from job to job as is shown in table 2, with a minimum of 3 men on one project and a maximum of 23 men on another project. The average number of men on all 34 projects was 13.

The handling and setting of forms consists in removing the forms from the finished and hardened pavement, transporting and distributing them where they are to be reset, shaping the form trench, setting, lining up and pinning the forms to the subgrade, and, finally, checking the form line. The number of men used to perform this operation varies considerably, although the methods are more or less standardized. The average number of men required was 11. The chief reasons for variation in the number of men employed are the

TABLE 1.—*Summary of equipment used on projects studied in 1929 and 1930*—Continued

	Ohio no. 1	Oregon no. 1	South Carolina no. 1	Tennessee no. 1	Tennessee no. 2	Tennessee no. 3	Tennessee no. 4	Tennessee no. 5	Tennessee no. 6	Tennessee no. 7	Tennessee no. 8	Texas no. 1	Texas no. 2	Washington no. 1	Washington no. 2	Washington no. 3	Washington no. 4	Washington no. 5	Wisconsin no. 1
GENERAL INFORMATION																			
Length of project, miles	4.9	4.7	19.8	13.8	12.0	14.2	8.1	12.4	10.4	4.7	10.9	13.9	30.4	8.1	7.8	6.4	4.1	6.6	14.7
Width of pavement, feet	30	20	18	18	18	18	18	18	18	18	18	18	18	20	20	18	18	20	20
Average length of haul during study, miles	2.4	2.3	2.2	2.0	2.6	2.3	5.8	8.0	6.0	2.0	2.5	1.9	1.7	0.9	7.3	4.0	4.5	6.4	2.4
FINE GRADING																			
Blade graders, number and length of blade, feet	1-10	2-8	1-8	1-12	1-12	1-12	1-12	1-10	1-10	2-10	1-10	1-10	1-8 1-10	1-12	1-10	1-10	1-10		1-10
Tractors, number and horsepower	1-30	1-20	1-20	1-60	1-75	1-60	1-50	1-60	2-30	1-50	1-50	1-30	1-30 1-60	1-30 1-60	1-30	1-30	1-30		1-30 1-60
Motor patrols, number and length of blade, feet																		1	
Scarifiers, number	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1
Subgraders, number	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Subgrade planers, number	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rollers, number and size, tons	2	1-10	1-10	2	1-5	1-10	1-10	2	1-10	1-5	1-5	1-3	1-5	1-10	1-12	1-12	1-14	1-12	1-5
Fresno teams, number	1	1		1	1	1	1	1	1	4	3	2		2	1	2		1	1
HANDLING FORMS																			
Lineal feet	2,176	4,600	3,000	5,000	3,500	5,200	3,940	4,600	5,000	5,500	2,060	4,000	4,400	28,600	42,000	15,000	20,000	40,000	38,500
Forms, kind	Steel	Wood	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Wood	Wood	Wood	Wood	Wood	Steel
Wagon teams, number			2		2	1	1		1			1	1						
Trucks, number	1	1		2						1	1			1	1	1	1	1	
Mechanical form trenchers, number		1						1				1							
HANDLING MATERIALS																			
Cranes, number and capacity, cubic yards	2-1	1-2	2-¾	1-1	1-¾	1-1	1-¾	1-1	1-¾	1-¾	1-1	1-1	1-1¼	1-1¼	1-1¾	1-1¼	1-1	1-1¾	1-1¾
Batcher bins, number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tractors, number	1		1																
Cement houses, number	1		1			1	1	1		1	1	2				1			
Pumps, number	1	1	1	1	1	2	2	1	2	1	1	1	2	3	1	1	1	1	
Pipe:																			
3-inch, lineal feet						10,000								26,400	31,000	15,000	13,200		
2½-inch, lineal feet	40,000	22,000	21,000		5,300	19,040	21,120			21,120	20,000	22,000	40,000					19,000	
2-inch, lineal feet				15,935	15,800			25,000	42,400			10,000							40,000
Hose:																			
2-inch, lineal feet		300		200	200	200				100	150		300	300				300	200
1½-inch, lineal feet	200		300		100				150						550	350	300		
1-inch, lineal feet												175							
Service trucks, number		1	1	1	1	1	2	1	1	1	1	1	3	1			1	1	2
HAULING BATCHES																			
Trucks:																			
4-batch, number																		3	
3-batch, number	12	5						16	10										
2-batch, number			10	10	11	10	13			9	10			5	13	10	10	8	10
1-batch, number			2									15	21						
Turntables				1		1	1	1				1							1
MIXING																			
Paving mixers (all 27-E), number	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FINISHING																			
Strike boards, number and length, feet		1												1-20	1-20	1-20		1-20	
Finishing machines, number and width, feet	2-20		1-18	1-18	1-18	1-18	1-18	1-18	1-18	1-18	1-18	1-18	1-18				1-18		1-20
Longitudinal floats, number and length, feet		1-11	1-12	2-16	1-16	2-16	2-16	2-16	2-16	1-10	1-10		1-18	1-16	1-16	1-16	1-16	1-16	1-10
Transverse floats, number and length, feet						1-18	1-18	1-18	1-18					1-20	1-20	1-18	1-18	1-20	1-20
Rollers, number												1		1	1	1		1	
Belts, or flexible floats, number and length, feet			1-18	1-18	1-18	1-18	1-18	1-18	1-18	1-20	1-20	1-18	1-18	1-20		1-16		1-18	2-20
Joint machines, number and width, feet	1-20																		1-20
Hand floats, number	2	2		2	2	2	2	2	2	3	3	2	2	4	9	5	3	5	2
Straight edges, number												1		1	1	1	1	1	
CURING																			
Burlap, length, feet	1,500	1,000	2,000	1,000	825	1,200	2,000	1,000	1,500	1,500	1,500	1,200	1,500	1,000	1,000	800	1,100	1,000	1,000
Hose, ¾-inch, feet	300	300		300	300	200	300	300	1,000	600	300	350	300	700	700	400	450	900	400
Curing spray apparatus, number													1						

method used in trenching, the accuracy with which form trenching is done, the rate at which forms must be set to keep pace with paving, the character of the soil, and the efficiency of form-handling and setting operations.

The average number of men employed in handling materials is 14. This includes the men operating the water-supply system.

The number of men, including truck drivers, truck checkers, dumpers, and turntable operators employed to deliver batches to the paver ranged from 5 to 30. Reasons for this wide variation are length of haul, condition of hauling road, condition and capacity of hauling equipment, rate of paver operation; and efficiency of hauling equipment operation. On an average, 15 men were employed in hauling batches on the 34 projects on which the average length of haul during the period of study varied from 0.9 mile on one project to 10 miles on another, and on which 1-, 2-, 3-, and 4-batch trucks were used.

The men connected with the mixing operation are the foreman, who usually has charge of mixing, placing, finishing, and curing, and the paver operator.

The men employed in finishing, which in this summary includes puddlers, spaders, finishing machine operators, strikeboard laborers, hand finishers on slab

TABLE 2.—*Summary of personnel on 38 concrete paving projects, 1929–30*

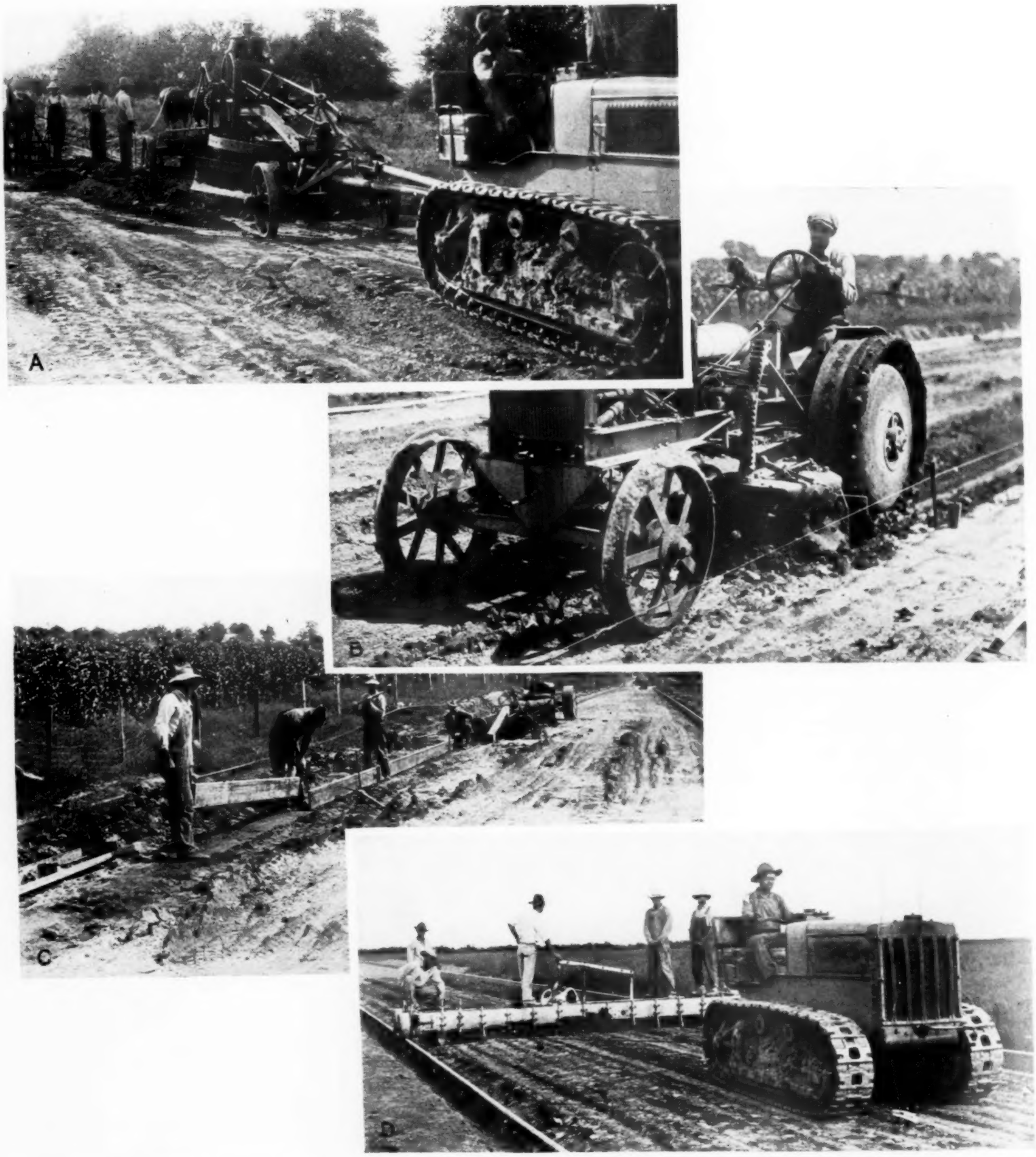
	Arkansas no. 1	California no. 1	California no. 2	California no. 3	California no. 4	California no. 5[1]	Colorado no. 1	Iowa no. 1	Louisiana no. 1	Louisiana no. 2	Louisiana no. 3	Louisiana no. 4	Maine no. 1	Michigan no. 1	Missouri no. 1	New Jersey no. 1	Ohio no. 1[1]	Oregon no. 1	Tennessee no. 1
Fine grading:																			
Foremen	1		1		1	1		1	1	1	1	1	1	1	1	1	1	1	1
Tractor operators	1		2	1	2	2		1	1	1	1	1		1	2	1	1	1	1
Blade-grader operators	1		1	1	1	2		1	1	1	1	1		1	1	1	1	1	1
Roller operators	1		1		1	1		1	1		1	1	1	1	1	1	1	1	1
Teamsters or drivers	2		1	1	2	2		2			3	2			5				
Laborers ahead of mixer	8	3	3		6	6	6	4	8	2	7	3	11	8	9	6	6		7
Laborers rear of mixer			2				5	2	2	2	3	1		2			4		2
Total	14	3	11	3	13	14	11	12	14	7	17	10	13	14	19	10	14	4	13
Handling and setting forms:																			
Foremen	1	1	1		1	1		1						1		1	1	1	1
Form setters	3	2	2	2	3	2	2	4	3	4	3	4	1	1	3	4	2	2	3
Helpers	3	2	2	2	3	2	2	4	3	3	2	3	1	1	3	3	2	1	
Teamsters	2							2		2	2			1	1		2		
Truck drivers		1	1	1	1	1	1		2		1	1	1			1	1	1	2
Laborers	7	6	14		8	10	2	10	1	5	1	4		1	2	4		2	4
Total	16	12	20	5	16	16	7	21	9	14	9	12	3	5	9	13	8	7	10
Handling materials:																			
Foremen at plant			1		1	1		1						1				1	1
Crane operators	2	1	1	1	1		1	2	2	1	1	1	1	1	1	1		2	1
Batcher operators	1	1	1	1	1	2	1	1	1	2	1	2	1	1	1	2	2	1	1
Laborers in cars		2		1			3	2		2	1	2	1	3	3	2	2		3
Cement handlers, loading	5		3	3	5	4			2	2	3	4	2	3	3	2			2
Cement handlers, dumping	2	4	3	3	4	4	4	6	3	2	3	2	3	2	2	3	6		3
Sack shakers, balers	1	1			1					1					1				2
Pump operators	1		1	1	1		1	2	1	1	1	1	1	1	1	1	1	1	1
Laborers on pipe line	2					2	2	3			1		1		2				
Laborers			2			3						1	1		1	3	7		3
Service truck drivers		1		1	2	2	1	2	2		1				1		1		1
Total	14	10	12	11	16	18	13	19	11	11	12	13	11	12	16	14	19	5	18
Hauling batches:																			
Truck foremen		1															1		
Truck drivers	17	7	7	4	20	18	18	34	29	17	13	11	8	11	17	7	12	5	11
Truck checkers	1						1	1	1		1				1				
Turntable operators	1	1	1		1		1	1		1	2				2				1
Truck dumpers	1	1	1	1	2	2	2	1	1	2	1	1	2	1	1	1	4	1	1
Total	20	10	9	5	23	20	22	37	31	20	17	12	10	12	21	8	17	6	13
Mixing:																			
Foremen	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mixer operators	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	2	1	1
Total	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	3	2	2

	Tennessee no. 2	Tennessee no. 3	Tennessee no. 4	Tennessee no. 5	Tennessee no. 6	Tennessee no. 7	Tennessee no. 8	Texas no. 1	Texas no. 2	Washington no. 1	Washington no. 2	Washington no. 3	Washington no. 4	Washington no. 5	Wisconsin no. 1	Illinois no. 1[1]	Nebraska no. 1	Missouri no. 2[1]	South Carolina no. 1
Fine grading:																			
Foremen	1	1	1	1	2	1	1		1	1	1	1	1	1	1	1	1	1	1
Tractor operators	1	1	1	1	1	1	1	1	2	2	1	1	1	1	2		1	2	1
Blade-grader operators	1	1	1	1	1	1	1	1	2	1	1	1	1		1	1	1	2	
Roller operators	1	2	1	1	2	1	1	1	1		1	1	1	1	1	1	1		1
Teamsters or drivers						4	3	2		2	1	2		1		2	3		
Laborers ahead of mixer	8	12	9	8	5	15	10	5	10	5	4	1	9	8	6	11	4	4	12
Laborers rear of mixer				2	2	2	2	2	4	4	3	3	4	4	2	2	2	4	4
Total	12	17	13	14	13	25	19	12	20	15	12	10	17	16	13	18	13	13	19
Handling and setting forms:																			
Foremen	1	1	1	1		1	1			1		1		1					
Form setters	4	4	3	4	5	4	3	2	2	2	2	2	3	2	1	6	3	1	4
Helpers	3	3	3	3		3	3	2	2	1	2	1	2	1	1	4	4	8	3
Teamsters	2	2	2	2	2			1	1								2	3	2
Truck drivers						1	1			1	1	1	1	1	2	1			
Laborers	4	4	7	7	1	3	10	4	1		3	1	3	1	2	5	5	7	1
Total	14	14	16	17	8	12	18	9	6	5	8	6	9	6	6	16	14	19	10
Handling materials:																			
Foremen at plant	1						1		1		1			1		1	1	1	1
Crane operators	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	2	2	2
Batcher operators	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	3	1	1	1
Laborers in cars	2	2	2	2	2	2	2	3	2	2	1	1		1					
Cement handlers, loading	3	3	4	3	3	3	3	2	4	2		6			3	2		7	6
Cement handlers, dumping	3	3	2	3	3	2	2	2	2	3	3	2	3	3	3	1	7	4	6
Sack shakers, balers	1			1	1		1						1	1	1				
Pump operators	1	2	1	1	1	2	1	1	1	1	1	1		1	1	1	1		1
Laborers on pipe line	2	4		3			2		3	3	2			2		2	2		
Laborers		2					4	3	1	1	1	1	1	1		3	2		6
Service truck drivers	1	1	2	1	1	1	1	1		1			1		1	2	1	1	1
Total	16	19	13	16	15	12	19	14	17	15	11	13	8	12	12	16	17	16	24
Hauling batches:																			
Truck foremen								1								6		1	
Truck drivers	11	10	13	15	9	9	10	15	24	5	13	10	10	11	10	2	27	35	11
Truck checkers	1	1							1										
Turntable operators		2	2	1				1	1							8		2	1
Truck dumpers	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1		1	2	
Total	13	14	16	17	10	10	11	18	30	6	14	11	11	12	11	16	28	40	12
Mixing:																			
Foremen	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1
Mixer operators	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1
Total	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	5	2	3	2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Finishing:																			
Foremen	1																	1	1
Puddlers	4	3	5	5	4	5	2	4	2	3	3	3	5	4	4	5	5	2	3
Spaders	-	2	-	-	1	2	-	-	-	-	-	-	-	-	-	-	2	-	-
Finishing-machine operators	1	2	1	2	1	2	1	1	1	1	1	1	1	1	1	1	2	-	1
Strikeboard laborers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Finishers, floating slab	4	4	9	4	10	6	4	2	7	2	4	2	4	2	2	4	2	3	4
Finishers, joints and edging	2	5	4	3	7	6	2	3	-	-	-	-	-	1	2	-	3	3	-
Total	12	16	19	14	23	21	9	10	10	6	8	6	10	8	9	10	14	11	9
Setting steel:																			
Laborers, reinforcement	-	3	4	2	5	7	-	1	-	-	-	-	-	4	-	2	2	-	-
Laborers, longitudinal joints	2	-	-	-	-	-	-	-	2	2	2	2	4	-	1	-	-	4	2
Total	2	3	4	2	5	7	-	1	2	2	2	2	4	4	1	2	2	4	2
Curing:																			
Foremen		1			1	1	1												1
Laborers on burlap	2	2	2	2	2	2	3	2	2	2	2	4	1	2	-	-	2	2	2
Laborers, covering and sprinkling	8	5	9	5	10	9	9	12	2	2	5	2	1	3	2	1	5	3	12
Total	10	8	11	7	13	12	13	14	4	4	7	6	2	5	2	1	7	5	15
Supervision:																			
Superintendent	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1
Timekeepers	1	1	1	1	2	1	1	2	1	1	1	1	1	1	2	1	2	1	1
Total	2	2	2	2	3	2	2	3	2	2	2	2	2	2	3	2	4	2	2
Miscellaneous:																			
Laborers	3	-	-	1	2	-	2	-	2	-	-	1	-	-	1	1	12	-	-
Watchmen	2	-	-	-	-	-	1	1	1	1	-	1	-	1	-	1	2	-	1
Mechanics	1	1	1	1	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Waterboys	1	-	-	-	-	-	-	1	-	1	-	1	1	1	1	1	2	1	2
Total	7	1	1	2	4	-	3	2	3	2	-	3	1	3	2	3	16	1	3
Total, excluding truck drivers, steel crew, and miscellaneous	73	56	79	45	89	88	61	84	54	49	61	52	45	49	64	53	74	37	71
Total, excluding truck drivers and steel crew	80	57	80	47	93	88	64	86	57	51	61	55	46	52	66	56	90	38	74
Total, excluding truck drivers	82	60	84	49	98	95	64	87	59	53	63	57	50	56	67	58	92	42	76
Grand total personnel	99	67	91	53	118	113	82	121	88	70	76	68	58	67	84	65	104	47	87

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Finishing:																			
Foremen			1					1	1							1			
Puddlers	4	3	3	3	3	2	4	4	7	5	3	4	3	3	3	6	2	6	5
Spaders	-	-	-	-	-	2	2	2	-	-	-	-	-	-	-	-	-	6	-
Finishing-machine operators	1	1	1	1	1	1	1	1	1	-	-	-	1	-	1	1	1	1	1
Strikeboard laborers	-	-	-	-	-	2	6	-	-	2	2	2	4	2	-	-	-	4	-
Finishers, floating slab	4	4	4	4	4	5	4	2	4	4	7	5	2	7	4	2	4	6	2
Finishers, joints and edging	-	-	1	-	-	-	-	1	2	2	2	2	2	2	4	1	6	1	3
Total	9	8	10	8	8	12	17	11	15	13	14	13	12	14	12	11	13	24	11
Setting steel:																			
Laborers, reinforcement	-	-	-	-	-	-	-	2	3	-	-	-	-	-	3	-	-	-	-
Laborers, longitudinal joints	2	2	2	1	2	1	2	1	1	-	-	-	-	-	2	1	1	2	-
Total	2	2	2	1	2	1	2	3	4	-	-	-	-	-	5	1	1	2	-
Curing:																			
Foremen	1					1	1	1		1	1								
Laborers on burlap	2	2	2	2	2	2	2	2	3	2	2	2	2	2	5	1	2	2	2
Laborers, covering and sprinkling	2	9	5	6	11	4	3	7	9	11	2	3	2	3	4	2	3	2	8
Total	5	11	7	8	13	7	6	10	12	14	5	5	4	5	9	3	5	4	10
Supervision:																			
Superintendent	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Timekeepers	-	1	1	1	1	1	1	1	1	2	1	-	-	-	1	1	2	1	1
Total	1	2	2	2	2	2	2	2	2	3	2	1	1	1	2	2	3	2	2
Miscellaneous:																			
Laborers	-	7	-	-	-	7	-	1	-	-	2	-	3	-	1	4	1	1	1
Watchmen	1	2	1	1	1	1	1	2	1	1	1	-	-	-	-	2	2	1	-
Mechanics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	4	1
Waterboys	2	2	2	2	-	2	3	-	1	-	1	-	-	1	-	2	1	-	1
Total	3	11	3	3	1	10	4	3	2	1	4	-	3	1	2	9	6	6	3
Total, excluding truck drivers, steel crew, and miscellaneous	61	77	66	69	62	73	84	63	80	68	55	51	54	57	57	71	68	86	79
Total, excluding truck drivers and steel crew	64	88	69	72	63	83	88	66	82	69	59	51	57	58	59	80	74	92	82
Total, excluding truck drivers	66	90	71	73	65	84	90	69	86	69	59	51	57	58	64	81	75	94	82
Grand total personnel	77	100	84	88	74	93	100	84	110	74	72	61	67	69	74	97	102	129	93

[1] 2 pavers were used on project.
[2] 2 pavers were used and an industrial railway was used for hauling batches. Under personnel for "Batch hauling" are listed 6 operators, 2 brakemen, and 8 in section crew.



A, shaping the subgrade with a tractor-drawn grader; *B*, excavating trench for forms; *C*, setting and lining up forms; *D*, the "subgrader" does the final shaping, leaving excess material in furrows for removal by hand shovels or fresnos.

STEPS IN SHAPING THE SUBGRADE.

and on joints, varied from a minimum of 6 to a maximum of 23 with an average of 11.

Setting steel, which includes both the longitudinal steel joint and reinforcing steel, required an average of 2 men on each of the 34 projects. The number varied from 1 to 7 for individual projects. On several projects neither longitudinal joint steel nor reinforcing steel was used.

The number of men employed in curing the concrete varied from 1 to 15, depending on the method of curing, the amount of slab to be cured and the efficiency with which the curing operation was performed. An average of 8 men was used for this work.

TABLE 3.—*Analysis of number of men required for different operations*

Operation	For 34 projects using a single paver							Average number of men on 4 projects using 2 pavers
	Number of projects employing numbers of men between						Average number of men	
	0-5	6-10	11-15	16-20	21-25	26-up		
Fine grading	3	4	18	8	1		13	15
Handling and setting forms	4	15	8	6	1		11	15
Handling materials	1	2	20	10	1		14	17
Hauling batches	1	8	12	6	3	4	15	23
Mixing	34						2	3
Finishing		16	14	3	1		11	18
Setting steel	34						2	3
Curing	13	12	9				8	7
Miscellaneous	30	3	1				3	8
Supervision	34						2	2
Grand total all personnel							81	111
Total exclusive of truck drivers							68	90

TABLE 4.—*Labor and equipment required on average concrete paving project as estimated from study of 34 projects*

FINE GRADING

	Number and type of equipment units	Number and class of men employed
Blade grader	1, 8 to 12-foot blade	1 foreman.
Tractors	1, 30 to 75 horse-power	1 tractor operator.
Scarifiers	1	1 blade grader operator.
Subgraders	1	1 roller operator.
Subgrade planers	1, heavy, metal	2 teamsters.
Rollers	1, 3 to 15-ton	2 laborers in rear of paver.
Fresnos	2, 3-foot	
Fresno teams	2, 2-horse	5 Laborers ahead of paver.
Total		13

HANDLING AND SETTING FORMS

Forms, lineal feet	4,300 steel	1 form foreman.
Teams	1, 2-horse	2 form setters.
Trucks	1	2 form setters' helpers.
Form trenchers	1	1 teamster or truck driver.
		1 teamster's helper.
		4 laborers.
Total		11

HANDLING MATERIALS

Crane	1, ½ to 2 cubic yard capacity.	1 plant foreman.
Batcher bins	1	1 crane operator.
Cement house	1	1 batcher operator.
Pumps (water)	1 to 3	2 laborers in cars.
Pipe line, lineal feet	25,000, 2, 2½, 3-inch	6 cement handlers, load, dump.
Hose, lineal feet	250	
Truck service	1	1 laborer on pipe line.
		1 pump operator.
		1 truck driver, service.
Total		14

HAULING BATCHES

Trucks	Variable 1 to 4 batches	13 truck drivers, variable.
Turntable	1	1 truck dumper.
		1 turntable operator or truck checker.
Total		15

MIXING

Pavers	1, 27-E	1 foreman.
		1 paver operator.
Total		2

TABLE 4.—*Labor and equipment required on average concrete paving project as estimated from study of 34 projects*—Continued

FINISHING

	Number and type of equipment units	Number and class of men employed
Finishing machine	1	4 puddlers and spaders.
Floats	1 to 3	1 finishing machine operator.
Belts	1	3 hand finishers, slab.
Small tools		2 hand finishers, joints.
Bridges	4	1 hand finisher, edging.
Total		11

SETTING STEEL

		2 laborers.

CURING

Burlap, road feet	1,300	2 laborers, burlap.
Hose, ¾-in., lineal feet	400	6 laborers, covering.
Curing agent apparatus		
Total		8

MISCELLANEOUS

		1 watchman.
		1 water boy.
		1 mechanic.
Total		3

SUPERVISION

		1 superintendent.
		1 timekeeper.
Total		2
Total exclusive of truck drivers		68
Grand total		81

SHAPING THE SUBGRADE.

The equipment and the personnel on the average project, as judged from 34 projects, are shown in table 4, which gives the approximate distribution of personnel performing each operation. This table shows an average of 68 men employed to operate a modern paving outfit exclusive of the operators of hauling equipment. "Miscellaneous" as used in table 4 includes watchman, water boy, and mechanic. "Supervision" includes the superintendent and timekeeper.

Table 2 shows that the total personnel exclusive of truck drivers and steel crew on the paving projects employing a single 27-E paver varied between 38 and 93, a difference of 55 men.

In general, the number of men employed to operate a concrete paving outfit should be sufficient to perform all of the operations when the paver is working at maximum production. Considerable physical exertion is required of workers and assignments should be such that the work can be accomplished by uniform sustained effort and without injury to the men.

The type of supervision exercised over workers varies considerably. Some operations require a definite number of men regardless of the amount of work they have to do. Utilization of the capacity of workmen performing various operations may vary considerably. Again, the number of men that the contractor must employ to perform an operation may be and sometimes is regulated by arbitrary requirements of the engineer or inspector rather than by the amount of work to be done.

The number of men employed is regulated by a combination of the following influences: The maximum possible rate of production of the paver, the volume and character of fine grading, the lineal feet of transverse joints to be finished per square yard of pavement, methods employed, arbitrary requirements, type of supervision given, and extent to which machinery is used. It is believed that the combination of personnel and equipment employed on the majority of projects studied was sufficient to handle full paver production, and that the personnel in many instances was more than sufficient.

NO CONSISTENT RELATION FOUND BETWEEN NUMBER OF MEN EMPLOYED AND EFFICENCY OF OPERATION

To analyze the interrelation that may exist between number of men employed, maximum possible production, and over-all efficiency of paver operation, table 5 has been prepared, based on 23 of the projects studied. The information contained in this table is shown also in figure 1. There is a general relation between the number of men employed and the maximum possible rate of production although this relation is by no means definite. The relation between number of men and efficiency of paver operation is even less definite, showing that there are other factors besides production and efficiency which regulate the size of a working force.

TABLE 5.—*Comparison of number of men employed, over-all efficiency, and maximum possible production*

Project	Men employed exclusive of truck drivers and steel crew	Over-all efficiency, percent	Maximum possible production in cubic yards per hour [1]
Maine no. 1	46	66.4	40.7
California no. 3	47	47.4	50.6
Louisiana no. 2	51	82.1	39.6
Washington no. 3	51	81.8	42.5
New Jersey no. 1	56	76.0	38.6
Louisiana no. 1	57	87.2	41.0
Washington no. 4	57	96.8	51.5
Washington no. 2	59	87.9	51.2
Louisiana no. 3	61	80.3	44.0
Tennessee no. 6	63	86.4	44.7
Colorado no. 1	64	87.4	51.1
Tennessee no. 2	64	81.8	52.4
Louisiana no. 4	55	91.0	43.7
Texas no. 1	66	50.9	52.8
Tennessee no. 4	69	65.6	49.4
Washington no. 1	69	93.5	50.2
Tennessee no. 5	72	83.2	44.0
Nebraska no. 1	74	79.6	47.7
California no. 2	80	95.3	49.6
Texas no. 2	82	75.7	58.6
Tennessee no. 8	88	59.1	48.6
California no. 4	93	95.5	59.4
South Carolina no. 1	93	90.1	34.3

[1] The maximum possible production is regulated by the specified mixing time, the size of batch and the time constants of the paver for charging and discharging.

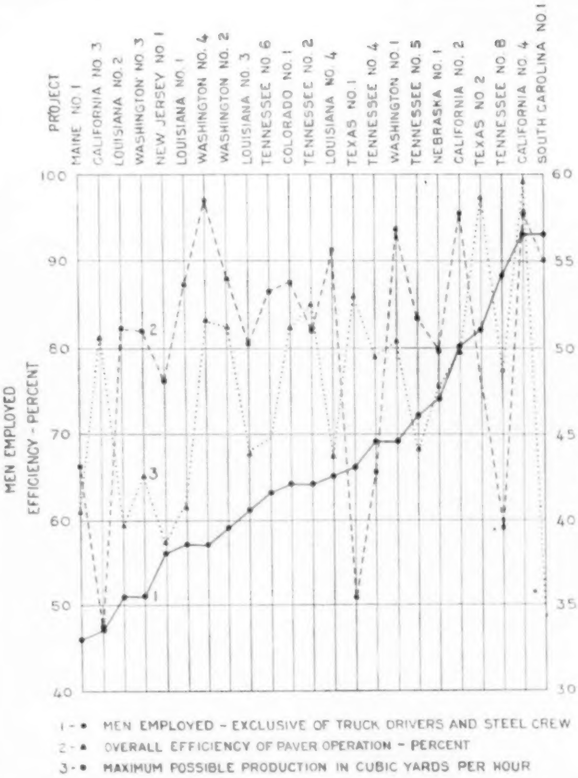
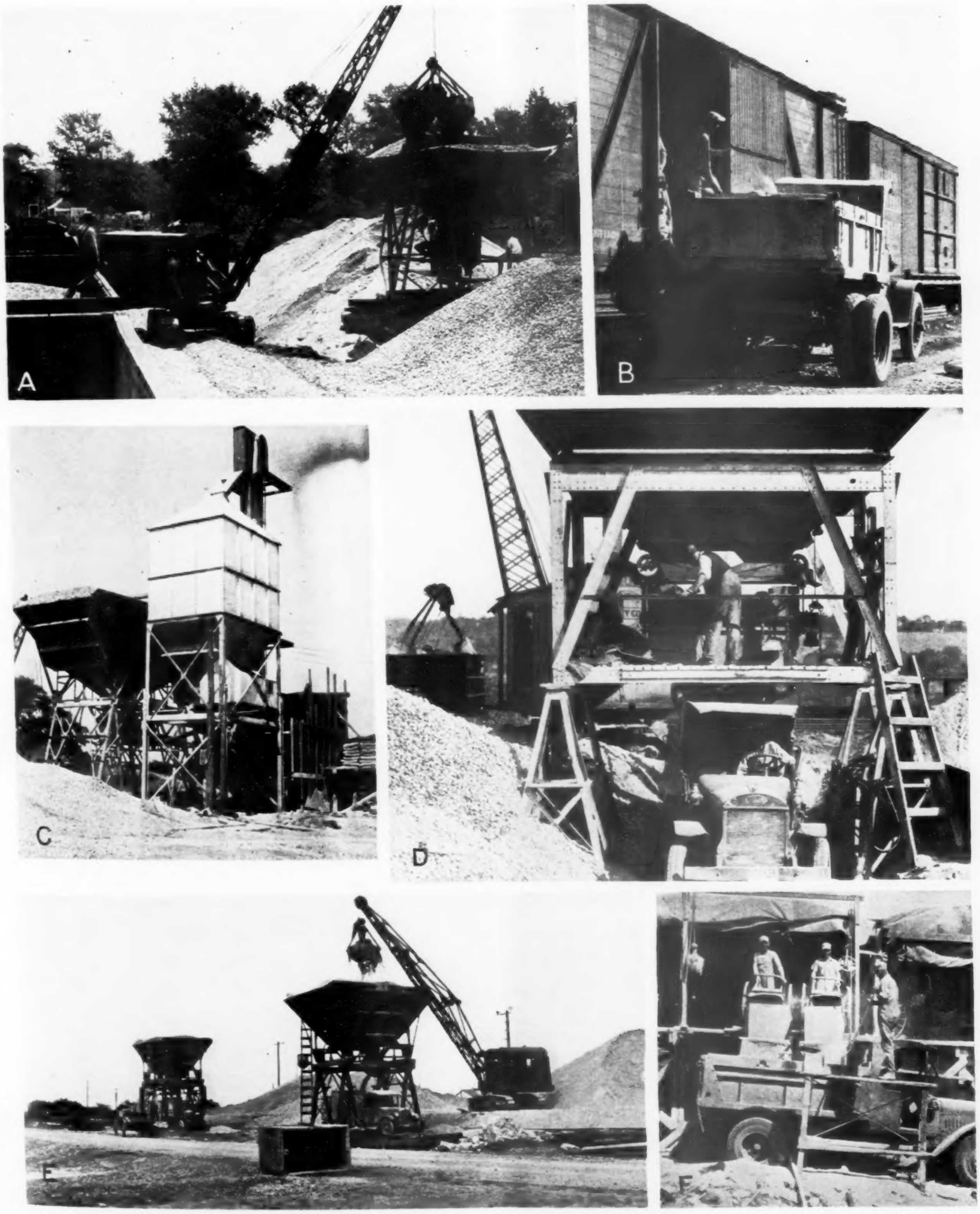


FIGURE 1.—RELATION BETWEEN SIZE OF FORCE, EFFICIENCY AND PRODUCTION.

TABLE 6.—*Comparison of number of finishers (finishing machine operator, spaders, and puddlers), lineal feet of transverse joint per square yard of pavement and maximum possible production*

Project	Number of finishers including finishing machine operator, spaders, and puddlers	Lineal feet of transverse joint per square yard	Maximum possible production in cubic yards per hour
Louisiana no. 2	6	None	39.6
Louisiana no. 4	6	None	43.7
Louisiana no. 3	8	None	44.0
Tennessee no. 3	8	0.018	48.0
Tennessee no. 5	8	.018	44.0
Tennessee no. 6	8	.018	44.7
Michigan no. 1	8	.09	44.9
Tennessee no. 1	9	.018	49.0
Tennessee no. 2	9	.018	52.4
Missouri no. 1	9	.09	36.8
Colorado no. 1	9	.15	51.1
Iowa no. 1	10	None	43.4
Louisiana no. 1	10	None	41.0
Tennessee no. 4	10	.018	49.4
Maine no. 1	10	.23	40.7
New Jersey no. 1	10	.26	38.6
Texas no. 1	11	.11	52.8
South Carolina no. 1	11	.22	34.3
Oregon no. 1	11	.45	40.6
Tennessee no. 7	12	.018	49.5
Arkansas no. 1	12	.18	47.5
Wisconsin no. 1	12	.18	44.0
Washington no. 4	12	.45	51.5
Nebraska no. 1	13	None	47.7
Washington no. 1	13	.45	50.2
Washington no. 3	13	.45	42.5
California no. 3	14	.45	50.6
Washington no. 2	14	.45	51.2
Washington no. 5	14	.45	52.7
Texas no. 2	15	.11	58.6
California no. 1	16	.45	52.0
Tennessee no. 8	17	.018	48.6
California no. 2	19	.45	49.6
California no. 4	23	.45	59.4

Table 6 gives the relation between the number of finishers (finishing machine operator, spaders, and puddlers), the lineal feet of transverse joint per square



A, crane unloading aggregates from cars to batcher bins or stockpiles as conditions require; *B*, unloading cement from cars to batch compartments of trucks; *C*, bin for handling bulk cement and batcher plant; *D*, batcher plant; *E*, a good plant arrangement; *F*, handling bulk cement in "buggies."

ARRANGEMENTS FOR HANDLING CEMENT AND AGGREGATES.

70225—34——2

yard of pavement and the maximum possible paver production on 34 projects. Figure 2 also shows this information. No direct relation between these factors is evident.

EFFICIENCY OF PAVER OPERATION IS GENERALLY AN INDICATION OF EFFICIENCY OF ENTIRE ORGANIZATION

The efficiency with which concrete paving is placed is indicated by the studies. It is true that the efficiency with which the paver is operated may or may not measure the efficiency of the paving outfit as a whole. The efficiency of the entire organization is of primary interest to the contractor in that it regulates his unit costs for personnel and equipment. It sometimes happens that, although the paver operates with a high degree of efficiency, it does so with an oversupply of hauling equipment. Other operations than hauling may also be over-equipped or over-manned. It may happen that the personnel and equipment for hauling, subgrade preparation, and other operations have a high degree of efficiency, while the paver has a low degree of efficiency. Or it may be that the paver operates at a consistently low rate, but because of that consistency the production can be handled by a reduced personnel. These conditions are the exception rather than the rule.

In general, the efficiency of the paver is a close indication of the efficiency of the entire organization which is in turn an index of the type of supervision employed. The contractor or superintendent who operates the paver efficiently is likely to be equally efficient in all operations. Similarly, inefficiency in paver operation is often attended by inefficiency in most other operations.

The paver is the key equipment on a concrete paving project and should set the pace for the entire paving organization. It has a maximum capacity of a definite number of batches per hour for the specified mixing time. It cannot exceed this production. When the production of the paver falls below this maximum number of batches the efficiency of the organization in general is lowered.

A definite number of men is required to operate the equipment and to perform nearly every operation. This number of men cannot be changed as the rate of production changes. The number required to operate the outfit at maximum production of the key equipment must be employed, for on the most inefficient jobs studied, there were times during nearly every day when the paver was operating at close to its maximum production.

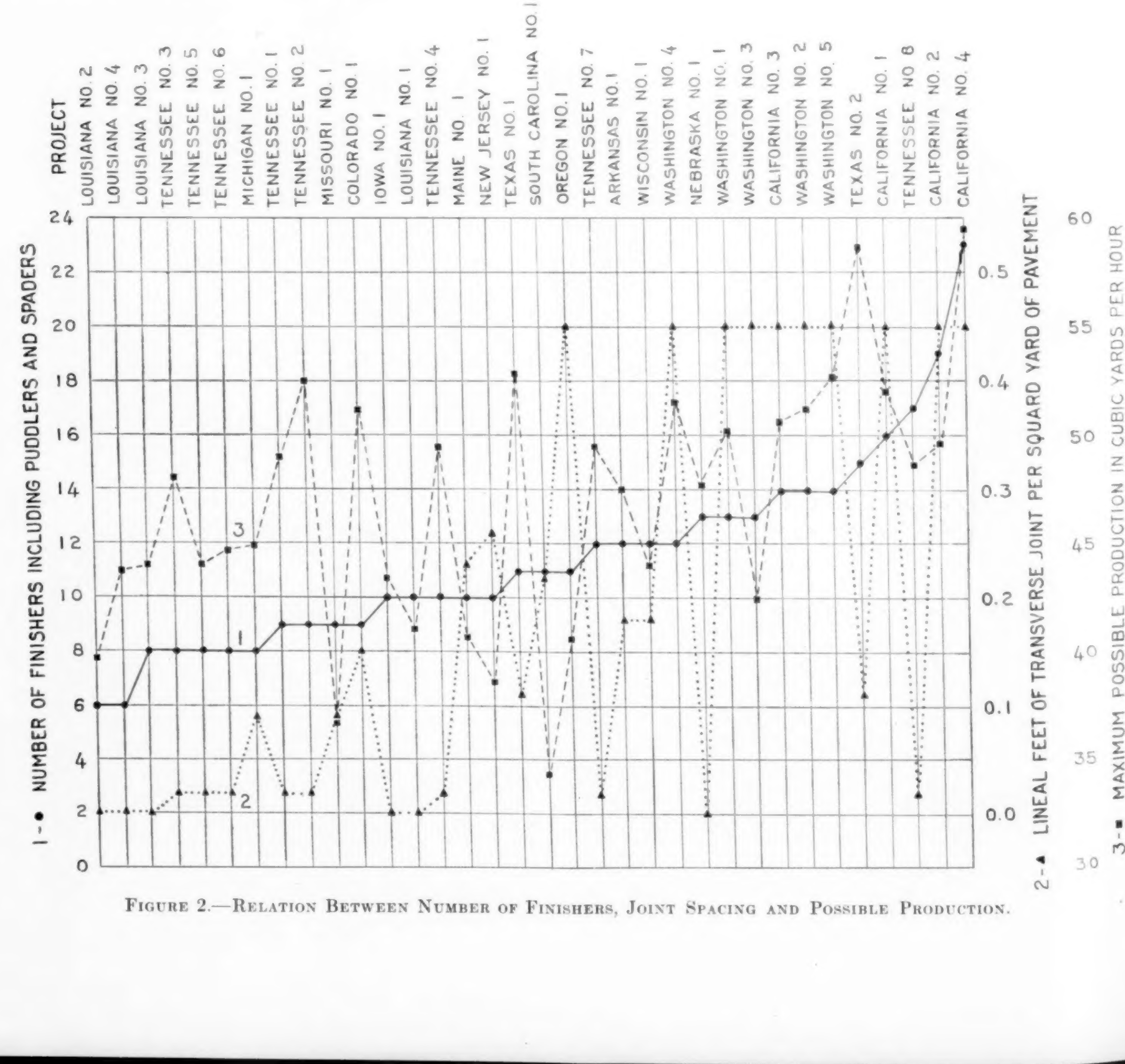


FIGURE 2.—RELATION BETWEEN NUMBER OF FINISHERS, JOINT SPACING AND POSSIBLE PRODUCTION.

Failure of outfits to maintain a high rate of production was not the result of insufficient personnel, but of intermittent delays of varying lengths. A high rate of production requires no greater rate of physical exertion on the part of workers than does a low and fluctuating rate of production.

Before discussing the efficiency of operation of major equipment, an outline will be given of the manner in which efficiency was determined. An engineer with one or more assistants was assigned to the project to be studied. In general, the duration of the study was from 1 to 2 months. During the study an accurate record was kept of the total available working time. The term "available working time" is defined as the time a crew was actually on the job, or the time it would have been on the job had there been no interference by the elements or other contingencies, consideration being given to the customs of the region and the practices of the contractor in regard to length of working day, holidays, etc. If a 9-hour day is customary with 7 hours work on Saturday, and holidays off, the available working time for a week in which no holiday occurs, will be 52 hours plus any overtime, regardless of how much time was actually lost because of rain, breakdowns, or other causes.

An accurate record was kept of all major delays. The term "major delays", as used throughout this report, indicates a delay of 15 minutes or more during the available working time. A delay of less than 15 minutes is termed a "minor delay." The division between major delay and minor delay at 15 minutes is chosen arbitrarily. In general, the major equipment will cease to operate during a major delay or the outfit may be shut down entirely as is usually the case during delays due to rain or wet subgrade. During the shorter major delays the entire organization may be on the job and drawing pay. The total available working time minus the total major delays gives the time the major equipment actually operated.

Minor delays are intermittent interruptions that range from a few seconds up to 15 minutes. Such delays are determined by stop-watch studies of operations. A stop-watch study period was usually of 1 hour's duration. From 2 to 4 such studies were made each day that the paver operated. The results of 2 stop-watch studies, 1 on a project operating with high efficiency and the other on a project operating with low efficiency, are shown in tables 7 and 8.

TABLE 7.—*Result of typical stop-watch study of project operating with high efficiency*

[Drum revolutions, 16.5 per minute.]

Charge	Mix	Discharge	Charge	Mix	Discharge	Delay due to— Operator	Mechanical causes	Miscellaneous causes	Split discharge
Sec.	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*
11	59	5	10	60	2	6	8	22	
10	59	5	11	61	3	3	38		7
10	58	2	11	61	3	1			
10	60	2	11	61	3				
10	61	3	10	61	2				
11	61	3	10	62	5				
11	61	3	11	58	3				
11	61	3	10	60	2				
11	60	2	11	62	2				
10	61	3	10	62	2				
10	60	5	11	62	3				
10	59	1	11	60	2				
10	59	2	11	62	5				
10	60	2	10	61	3				
11	61	5	11	62	2				
10	61	2	11	62	2				
10	62	2							
11	61	3							
11	60	2							
11	61	3							
11	61	2							
10	61	3							
10	61	3							
10	60	5							
11	60	1							
10	61	3							
10	61	5							
11	61	3							
11	61	2							
10	62	5							
11	61	4							
10	61	2							
Total			494	2,913	140	10	46	22	7
Average			10.5	60.7	2.9				

Length of study, 60.53 minutes.
Number of batches mixed, 48.
Total time lost, 85 seconds or 2.3 percent.
Time per batch, 74.1 seconds.

TABLE 8.—*Result of typical stop-watch study of project operating with poor efficiency*

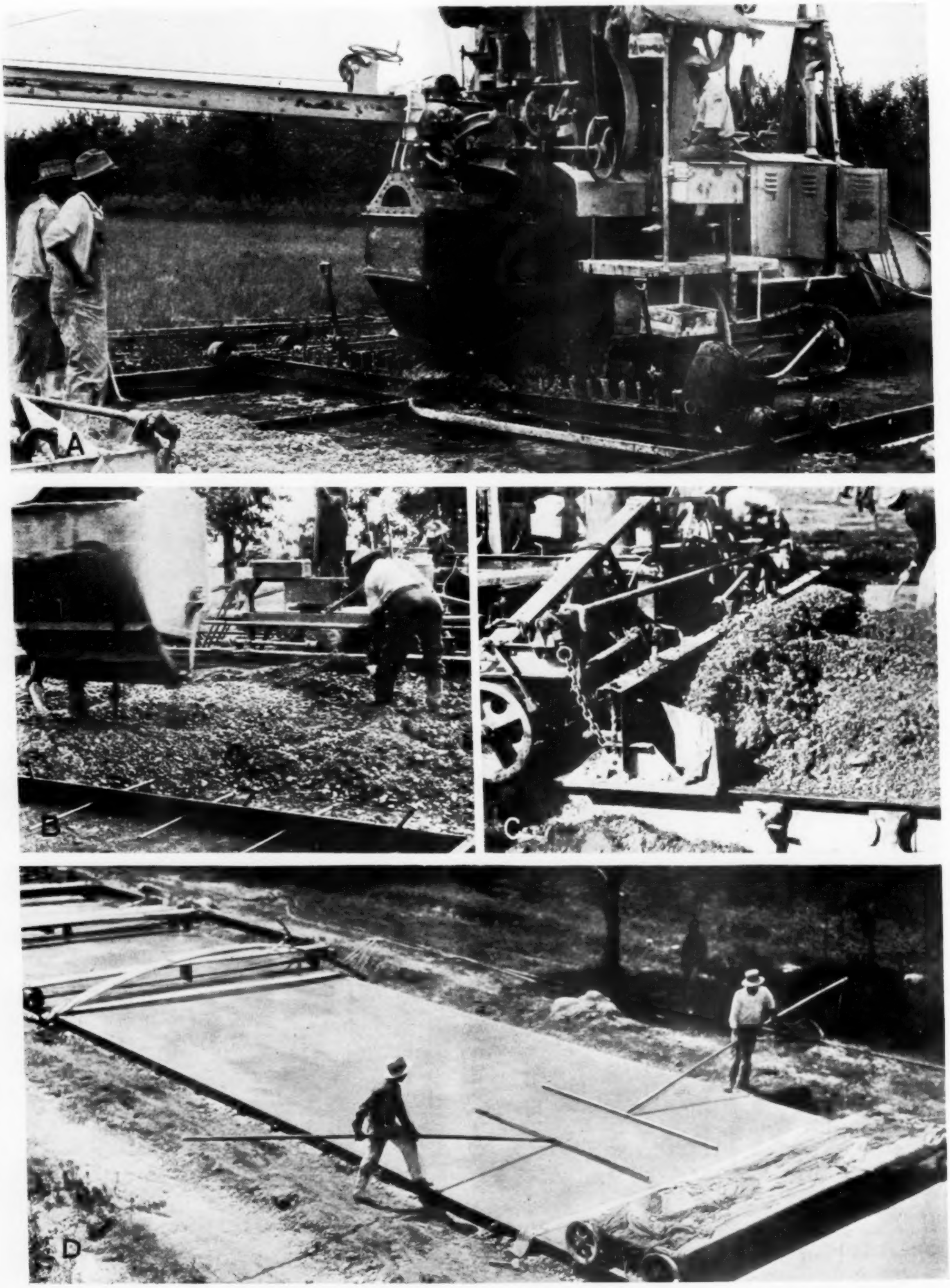
[Drum revolutions 15.5 per minute]

Charge	Mix	Discharge	Charge	Mix	Discharge	Delay due to— Split discharge	Dumping or turning	Subgrade unprepared	Operation of hauling equipment	Moving turntable	Changing hose
Sec.	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*
9	64	3	9	62	3	25					
9	62	3	9	62	3	27	25				102
9	62	3	9	63	3	26	24				51
9	63	3	9	63	3	24		87			
9	64	3	9	62	3	23					
9	62	3						70			
8	61	3							28		
9	62	3							27		
8	62	3				21					
8	62	3				17		22			
9	68	3				16					
9	63	3								251	
9	62	3				18					
8	62	3				21					
8	62	3						27			
8	62	3						19			
9	63	3				21					
8	62	3						19			
9	62	3						15			
8	62	3						31			
8	62	3							24		
9	62	3				13					402
9	63	3									
Total			243	1,750	84	252	49	290	79	251	555
Average			8.7	62.5	3.0						

Length of study, 59.2 minutes.
Number of batches mixed, 28.
Total time lost, 24.6 minutes or 41.5 percent.
Time per batch, 74.2 seconds.

PREVENTABLE DELAYS FOUND ON MANY PROJECTS

Analysis of these tables shows characteristics of paver operation and the factors affecting the rate of production. The production of a batch of concrete consists of three operations: Raising the paver skip to charge the drum, mixing the batch, and discharging the batch from the drum to the paver bucket. In correct operation the raising of the skip overlaps the discharge of the preceding batch. Whenever the paver ceases to perform one of the three operations its efficiency is lowered. The project reported in table 7 was operated with high efficiency. With a mixing cycle of 74.1 seconds, representing the time to charge, mix, and discharge, the maximum production possible was 48.5 batches per hour. The over-all efficiency on this project during the entire production study was 96.8 percent.



A, a standard type of paver with subgrade planer attached for smoothing irregularities in subgrade; *B*, depositing concrete on subgrade; *C*, finishing machine in operation; *D*, "straight-edging" the surface.

Mixing and Placing Concrete.

Table 8 shows stop-watch data taken on a project where the efficiency was low. Small intermittent delays ranging from a few seconds to several minutes account for the low efficiency. Nearly all of the delays could have been eliminated under good supervision such as was found on the first job mentioned. The mixing cycle was 74.2 seconds. The maximum production could have been close to 48 batches per hour. During the study period the production rate was 28.4 batches per hour. The over-all efficiency during the entire period of the production study was 50.9 percent.

Delays of 15 minutes or more occurring during a stop-watch study, were recorded as major delays and were excluded from the stop-watch study period. Periods of study were of such length and at such times that the minor delays recorded are typical of those occurring throughout the working day. The total minor delays recorded during study periods for a day were extended to cover the working time for that day. The time that the major equipment actually operated minus the minor delays is considered to be the time of operation at full efficiency.

Both the major and minor delays are divided into two classes. Class A delays, in general, include those time losses arising from the weather and other causes which could not have been anticipated and prevented under good management. The class B delays are those which should have been eliminated under good management, due allowance being made for conditions affecting the particular project.

The efficiency of operation of major equipment is indicated by expressing the time that the major equipment actually operated at full efficiency as a percentage of the time that it could have operated at full efficiency had all class B or avoidable delays, both major and minor, been eliminated. There are factors which may affect efficiency and which are not taken into consideration in this method of determining over-all efficiency. The specified mixing time is one of them. The operations which must be performed during the mixing period, such as movement of hauling equipment at the paver, dumping batches, filling water tank, changing hose, preparing subgrade in rear of paver, making provision for joints, and placing steel, are less likely to cause delays to the paver when it is operating with mixing time of 75 or even 60 seconds, than when operating with a 50-second mixing time. A paving outfit with a full season's work ahead of it is in a much more advantageous position and has a greater incentive to use a better type of equipment and more specialized personnel, and to attempt efficient operation than is the outfit at work on a project of only a few weeks' duration. This advantage is not generally appreciated as is evident from table 9 and figure 3, which show a lack of relation between length of project and over-all efficiency of operation of major equipment on 24 projects.

Another factor in this method of determining over-all efficiency is the ability of observers to classify delays as avoidable or unavoidable according to the definitions previously given. A classification of this kind is essential if efficiency of operation is to be determined with any high degree of accuracy. The total available working time is no indication of the time in which it was possible to operate, when delays beyond the control of the contractor have occurred or when it would not be profitable to avoid delay. The observers in these studies had investigated paving projects and are thought to have been well trained for the work. The classifications made by the observers depended on judgment and therefore may not always be correct but there was no practicable way of eliminating the personal factor.

TABLE 9.—*Comparison of over-all efficiency and length of project*

Project	Over-all efficiency	Length of project
	Percent	*Miles*
California no. 3	47	4.4
Texas no. 1	51	13.9
Tennessee no. 8	59	10.9
Tennessee no. 4	66	8.1
Maine no. 1	66	3.8
Texas no. 2	76	30.4
New Jersey no. 1	76	7.7
Nebraska no. 1	80	14.6
Louisiana no. 3	80	6.8
Tennessee no. 2	82	12.0
Washington no. 3	82	6.4
Louisiana no. 2	82	10.1
Tennessee no. 5	83	12.4
Tennessee no. 6	86	10.4
Louisiana no. 1	87	26.8
Colorado no. 1	87	15.6
Washington no. 2	88	7.8
South Carolina no. 1	90	19.8
Louisiana no. 4	91	9.5
Washington no. 1	94	8.1
California no. 2	95	8.5
California no. 4	96	5.4
Washington no. 4	97	4.1

FIGURE 3.—COMPARISON OF EFFICIENCY AND LENGTH OF PROJECT.

TURNTABLE FOR TRUCKS.

TRUCKS READY TO BACK TO PAVER.

DUMPING INTO SKIP OF PAVER.

MINOR DELAYS RESULT FROM NUMEROUS CAUSES

Table 10 is a typical weekly summary of time losses and their effect on production. It shows the total available working time for the week, the time lost through avoidable and unavoidable major and minor delays, the production obtained, and the over-all efficiency of operation of major equipment.

Table 11 is a summary of weekly summaries covering the production studies on 23 projects using a single 27–E paver each and on 4 projects using two 27–E pavers each. The over-all efficiency of paving outfits ranges from 47.4 percent to 96.8 percent. Of the 10,651 hours that were available for paving on projects using a single paver, the paver operated at full efficiency only 4,973 hours, or 47 percent of the total available working time. Had the class B delays, those which could be eliminated under proper management, been eliminated, full production could have been maintained for 6,366 hours. The over-all efficiency of these 23 paving outfits representing nearly every section of the United States is 78 percent. The causes for the major delays and the time losses resulting from them are shown in table 12. The causes for the minor delays are shown in table 13. The results of these studies are believed to be a fairly accurate estimate of the efficiency with which major concrete paving equipment is operated in the United States.

Table 11 shows considerable difference in the over-all efficiency with which different contractors operated the major equipment. Table 1 indicates that the major and auxiliary equipment was about the same on all projects. Concrete paving equipment is fairly well standardized and in most cases the auxiliary equipment has a capacity corresponding to maximum paver production.

TABLE 10.—*Typical weekly summary of time losses and their effect on production*

[Project, Maine No. 1; equipment, one 27–E mixer, batcher, trucks, finishing machine; available working hours, 57.17; estimated production, 1,640 batches, or 6,500 lineal feet]

Source of delay	Class A		Class B		Total major delays	
	Hours	Percent	Hours	Percent	Hours	Percent
MAJOR DELAYS OCCURRING DURING AVAILABLE WORKING TIME						
Hauling equipment supply			0.40	0.7		
Water supply			.25	.4		
Hose line			.28	.5		
Placing special steel	0.54	0.9				
Mechanical trouble at plant	1.24	2.2				
Waiting for finishers	2.95	5.2				
Total	4.73	8.3	.93	1.6	5.66	9.9
MINOR DELAYS OCCURRING DURING TIME OF ACTUAL OPERATION						
Hauling equipment operation			4.18	8.1		
Operator			1.10	2.1		
Handling cement			.63	1.2		
Placing steel			2.74	5.3		
Wet aggregate sticking in trucks			2.15	4.2		
Shifting hose and pipe line trouble			1.95	3.8		
Water supply			.38	.7		
Trouble at plant	0.29	0.4	.82	1.6		
Hauling equipment supply			.19	.4		
Mixer, mechanical	.14	.3				
Lack of subgrade and waiting for finishers	1.82	3.5				
Total	2.16	4.2	14.17	27.5	16.33	31.7

Major equipment operated 51.51 hours or 90.1 percent of available time.

Major equipment operated at 100 percent efficiency 35.18 hours or 68.3 percent of operating time. Possible operating time with all class B losses eliminated 50.28 hours. With all class B losses eliminated production would have been 2,344 batches. Over-all efficiency of operation of major equipment, 70 percent.

TABLE 11.—*Summary of time losses and efficiency of operation of major equipment*

	Total available working time	Major delays as percentages of total available working time: Class A[1]	Major delays as percentages of total available working time: Class B[2]	Percentage of total available working time that major equipment actually operated	Minor delays as percentage of the time that major equipment actually operated: Class A[1]	Minor delays as percentage of the time that major equipment actually operated: Class B[2]	Percentage of actual operating time that major equipment operated at full efficiency	Time major equipment operated at full efficiency	Possible operating time, all class B delays eliminated	Over-all efficiency of major equipment operation
PROJECTS USING A SINGLE 27–E PAVER										
	Hours							*Hours*	*Hours*	*Pct.*
California no. 2	456.0	32.1	0.5	67.4	1.1	3.9	95.0	292.0	306.2	95
California no. 3	168.0	9.5	41.9	48.6	5.1	9.0	85.9	70.1	147.8	47
California no. 4	370.7	12.9	0.0	87.1	3.4	4.3	92.3	298.1	312.0	96
Colorado no. 1	417.0	9.9	1.8	88.3	4.9	10.2	84.9	312.5	357.5	87
Louisiana no. 1	336.0	66.2	0.3	33.5	4.4	11.3	84.3	95.3	109.1	87
Louisiana no. 2	448.0	64.9	0.5	34.6	8.0	15.3	76.7	118.4	144.2	82
Louisiana no. 3	544.6	43.6	2.0	54.4	7.2	15.2	77.6	229.7	285.3	80
Louisiana no. 4	240.4	31.3	1.3	67.5	5.6	6.7	87.7	142.1	156.1	91
Maine no. 1	225.0	31.3	3.0	65.7	5.7	28.6	65.8	97.3	146.5	66
New Jersey no. 1	889.7	47.8	5.5	46.7	5.2	13.7	81.1	338.0	444.4	76
Tennessee no. 2	517.6	23.6	1.3	75.1	15.3	14.1	70.6	274.6	336.0	82
Tennessee no. 4	672.0	39.4	7.9	52.7	2.9	23.6	73.5	260.4	397.0	66
Tennessee no. 5	475.0	17.9	2.0	80.1	2.2	14.5	83.3	316.9	381.7	83
Tennessee no. 6	413.4	50.7	0.5	51.3	6.4	14.9	78.7	158.5	190.7	83
Tennessee no. 8	293.0	28.1	12.6	59.3	8.0	25.1	66.9	116.2	196.6	59
Texas no. 1	1,055.4	51.8	7.6	40.6	0.0	39.5	60.5	258.9	508.0	51
Texas no. 2	1,431.6	48.5	2.9	48.6	8.7	17.6	73.7	512.2	676.6	76
Washington no. 1	117.0	2.9	2.0	95.1	4.7	4.3	91.0	101.1	108.3	94
Washington no. 2	185.7	12.5	4.6	82.8	1.0	7.3	91.7	141.4	160.9	88
Washington no. 3	89.0	0.0	8.2	91.8	0.0	10.9	89.1	72.9	89.0	82
Washington no. 4	99.5	3.7	0.6	95.7	2.4	2.5	95.1	90.5	93.5	97
Nebraska no. 1	812.6	24.4	4.9	70.6	3.2	14.2	82.6	475.0	595.7	80
South Carolina no. 1	394.1	42.0	0.5	57.5	2.6	8.7	88.7	201.2	222.9	90
Total	10,651.3	37.3	4.2	58.5	5.0	15.2	79.8	4,973.3	6,366.0	78
PROJECTS USING 2 27–E PAVERS										
California no. 5[3]	191.6	16.1	3.6	80.3	1.1	2.8	96.1	147.8	159.1	93
California no. 5[3]	191.7	15.3	3.3	81.5	1.7	3.9	94.4	147.4	159.8	92
Missouri no. 2[4]	305.4	45.5	3.4	51.1	3.8	17.7	78.5	122.9	160.6	76
Ohio no. 2[4]	321.7	40.9	9.6	49.5	4.9	21.1	74.0	117.8	182.0	65
Illinois no. 1[5]	211.4	26.3	3.8	69.9	16.3	5.7	78.1	115.4	131.9	88
Total	1,221.8	31.4	5.1	63.5	5.4	10.4	84.2	651.3	793.4	82

[1] Unavoidable.
[2] Avoidable.
[3] One of two pavers operating side by side.
[4] Two pavers side by side.
[5] Two pavers, one behind the other. Material is delivered to first paver and mixed for part of required time and then fed to second paver for completion of mixing.

TABLE 12.—*Distribution of the major delays on 23 paving projects having a total available working time of 10,651 hours; the percentages are based on the total available working time*

Cause of delay	Major delays: Class A		Major delays: Class B	
	Hours	Percent	Hours	Percent
Rain	1,290.0	12.1		
Wet subgrade	1,006.8	9.4		
Cold weather or snow	482.8	4.6		
Moving outfit	421.1	4.0		
Lack of prepared subgrade	240.4	2.3	128.5	1.2
Lack of materials	152.7	1.4	76.4	.7
Mixer trouble, mechanical	106.3	1.0	11.7	.1
Inadequate water supply	46.4	.4	21.7	.2
Stopping work early before regular stopping time	36.9	.4		
Finishing machine trouble, mechanical	21.0	.2		
Hauling equipment, operation			14.7	.2
Hauling equipment, shortage			30.3	.3
Miscellaneous	168.9	1.5	159.5	1.5
Total	3,973.3	37.3	442.8	4.2

Total major delays, 4,416.1 hours or 41.5 percent.
Time major equipment actually operated, 6,235.2 hours or 58.5 percent.

TABLE 13.—*Distribution of minor delays on the 23 paving projects during the 6,235 hours that the major equipment was operating; the percentages shown are based on the actual operating time*

Cause of delay	Minor delays			
	Class A		Class B	
	Hours	Percent	Hours	Percent
Wet subgrade	16.0	0.3		
Lack of prepared subgrade	12.8	.2	95.2	1.5
Hauling equipment, operation	17.1	.3	191.6	3.1
Hauling equipment, shortage	72.1	1.2	282.5	4.5
Inadequate water supply	27.4	.4	48.3	.8
Mixer trouble, mechanical	71.8	1.1	20.0	.3
Mixer trouble, operative			94.6	1.5
Moving mixer	9.2	.1		
Waiting on finishing operation			13.2	.2
Handling cement			15.3	.2
Placing joints and reinforcing steel			46.6	.8
Shifting hose at mixer			15.9	.3
Miscellaneous	85.6	1.4	126.7	2.0
Total	312.0	5.0	949.9	15.2

Total minor delays, 1,261.9 hours or 20.2 percent.
Time major equipment operated at full efficiency, 4.973.3 hours or 79.8 percent.

Table 14 is a summary of time losses on a project having a high type of supervision and correspondingly efficient operation. On this project work was carried on during the winter months under unfavorable weather conditions, but even with this handicap a high rate of production was maintained during periods in which it was possible to work.

Table 15 shows the results of a study made on a project with inadequate supervision and a resulting low efficiency. Avoidable delays were forestalled on the first job, but were allowed to happen and to reduce efficiency on the second project.

TABLE 14.—*Summary of time losses on an efficiently managed project during entire period of study*

[Project, South Carolina no. 1; available working time, 394.1 hours; estimated production, 6,898 batches or 39,461 square yards]

MAJOR DELAYS OCCURRING DURING AVAILABLE WORKING TIME

Cause of delay	Class A		Class B		Total major delays	
	Hours	Percent	Hours	Percent	Hours	Percent
Wet subgrade	59.88	15.20				
Rain	52.75	13.40				
Cold weather	51.53	13.10				
Mixer trouble, mechanical	.50	.14				
Water supply	.25	.06	0.28	0.07		
Truck operation	.50	.14	1.54	.39		
Totals	165.41	42.04	1.82	.46	167.23	42.50

MINOR DELAYS OCCURRING DURING TIME OF ACTUAL OPERATION

Cause of delay	Class A		Class B		Total	
Shortage of hauling units	1.62	0.71	0.97	0.43		
Hauling units, operation	1.26	.56	8.67	3.81		
Mixer operator			7.08	3.11		
Subgrade			2.20	.97		
Mixer, mechanical	1.25	.55				
Setting joints			.18	.08		
Water supply	.75	.33	.59	.26		
Miscellaneous	.96	.42	.21	.09		
Totals	5.84	2.57	19.90	8.75	25.74	11.32

Major equipment operated 226.9 hours or 57.5 percent of available time.
Major equipment operated at 100 percent efficiency 201 hours or 88.7 percent of operating time. Possible operating time with all class B losses eliminated, 222.9 hours. With all class B losses eliminated production would have been 7,643 batches. Overall efficiency of operation of major equipment 90.3 percent.

TABLE 15.—*Summary of time losses on an inefficiently managed project during entire period of study*

[Project, Texas no. 1; available working time, 1,055.3 hours; estimated production 12,352 batches or 77,831 square yards]

MAJOR DELAYS OCCURRING DURING AVAILABLE WORKING TIME

Cause of delay	Class A		Class B		Total major delays	
	Hours	Percent	Hours	Percent	Hours	Percent
Rain and wet subgrade	295.07	27.9				
Cold weather	212.12	20.1				
Moving	23.50	2.2				
Mixer, mechanical	16.67	1.6				
Lack of subgrade			13.26	1.3		
Lack of materials			12.00	1.1		
Water supply			11.42	1.1		
Truck supply			5.08	.5		
Truck operation			.63	.1		
Miscellaneous			37.71	3.5		
Totals	547.36	51.8	80.10	7.6	627.46	59.4

MINOR DELAYS OCCURRING DURING TIME OF ACTUAL OPERATION

[No class A minor delays]

Cause of delay	Class B	
	Hours	Percent
Truck supply	38.1	8.9
Truck operation	41.6	9.7
Truck turning and backing operation	8.5	2.0
Mixer, mechanical	6.0	1.4
Mixer, operative	5.1	1.2
Water supply	8.5	2.0
Lack of subgrade	24.8	5.8
Finishing	8.1	1.9
Expansion joints	6.0	1.4
Miscellaneous	13.3	3.1
Charge and discharge mixer, mechanical	9.0	2.1
Totals	169.0	39.5

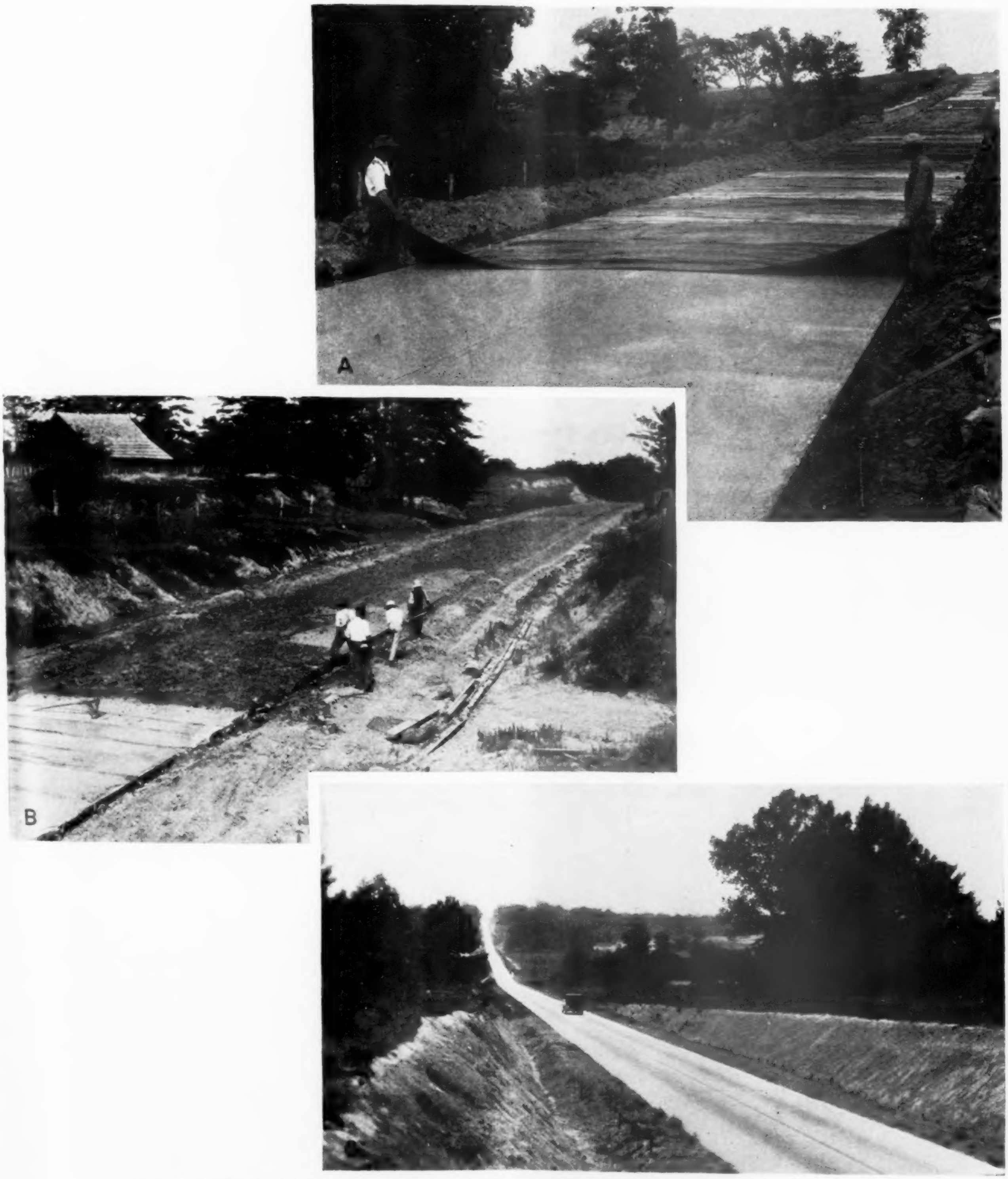
Major equipment operated 427.9 hours or 40.6 percent of available time.
Major equipment operated at 100 percent efficiency 259 hours or 60.5 percent of operating time. Possible operating time with all class B losses eliminated, 508 hours. With all class B losses eliminated production would have been 24,238 batches. Over-all efficiency of operation of major equipment 50.9 percent.

CAUSES OF INEFFICIENCY DISCUSSED

Constant and proper supervision is the key to efficient operation. The type of supervision on nearly every project listed in table 11 is indicated with fair accuracy by the figure for over-all efficiency of operation of major equipment. A superintendent who understands highway construction, who realizes the importance of utilizing available working time to the fullest extent, and who has the ability to foresee and to prevent delays, is highly valuable.

It is evident that adequate supervision has not always been employed. The first reason that comes to mind is that contracting firms, in general, have not always realized the value of adequate supervision of construction. Administrative officers devote a major portion of their time to obtaining contracts and purchasing materials and partially neglect measures for attaining efficiency in construction. It has been customary to refer to highway construction as a "risky business", and there has been a tendency on the part of highway contractors to place much of the blame for inefficient operation on the element of risk rather than on a lack of proper supervision.

Another reason for low efficiency may be that there is no large supply of highway superintendents who have



A, covering concrete with burlap after finishing; *B*, placing earth covering after surface has hardened; *C*, the finished surface.

STEPS IN CURING.

a natural aptitude for the work, together with adequate experience in methods of construction and such special training in production work as enables them to appreciate the value of advance planning and of full use of available working time. Possibly the seasonal and intermittent character of concrete road construction has led qualified men to seek continuous employment in other lines of work.

Another factor affects the efficiency with which highway construction work is done. This can be termed "inspectional interference."

Inspectional interference is not to be confused with proper and adequate action in the enforcement of specifications. Proper inspection is a necessity. It is a factor which can be evaluated with reasonable accuracy in preparing bid prices. Inspectional interference, on the other hand, is the overstepping of the engineer's or inspector's authority to enforce specifications. Arbitrary requirements may be imposed on the contractor. An element of risk may be introduced which cannot usually be evaluated, but which must be considered in arriving at bid prices.

The reasons for such interference are natural ones. In some instances specifications do not state clearly what is desired. They may be contradictory also. Unnecessary interference has been found on many of the projects studied. The actual extent to which it has lowered operating efficiency is not shown in the results of the production studies. The lost time caused by such interference has been reported under the type of delay which it caused.

Unnecessary interference causes a loss of working time and also tends to discourage the employment of adequate supervision when the efforts and planning of a competent superintendent can be easily frustrated by a well-meaning but over conservative and autocratic resident engineer or inspector.

Many examples of unnecessary interference could be cited. Contractors are sometimes required to mix the concrete longer than the specified mixing time, because, in the inspector's opinion, it results in better concrete. It actually results, however, in decreased production and increased costs for labor and equipment. The hours of work are sometimes arbitrarily regulated. Instances have been observed where production has been stopped for extended periods in order that the templates and finishing-machine screeds might be checked although there was ample opportunity for checking during nonoperating time.

A rather absurd instance of interference was observed not long ago. Laborers emptying sacks of cement on trucks were required by the engineer to leap through the air from one truck to the next rather than to descend to the ground after the dumping operation. This was done to prevent the loss on the ground of cement adhering to the laborers' shoes. The laborers, after dumping cement on one truck could not start on the next truck until it came alongside so that they could jump to it. With two trucks abreast between the forms there was not sufficient room for the empty truck at the paver skip to proceed without delay. The empty truck had to wait its turn to pick its way between loaded trucks engaged in this maneuver. The hauling service was badly disrupted. Hauling costs were increased and paver production was decreased.

The daily operating cost for labor and equipment on a concrete paving project is approximately $580 as will be shown later. The cost varies but little whether the production per day is 250 or 500 cubic yards of concrete. The importance of efficient operation in reducing unit costs should not be overlooked. Neither should the fact be lost sight of that an efficient organization is in a much more favorable position to produce concrete of good and uniform quality than is the inefficient and intermittently operated outfit. Inspectional interference will be difficult to eliminate so long as both the results desired and the methods by which the contractor must obtain these results are specified, and so long as authority over the operation of the contractor's personnel and equipment, without responsibility for the finished product, is assumed by the inspector.

UNIT COSTS PER SQUARE YARD ANALYZED

State practices vary with regard to pavement thickness, cement factor, length of mixing time, size of batch, amount of reinforcing, and joint material used, etc., and it is difficult to calculate accurately the unit cost for concrete pavements for the country as a whole. During 1930, 10,600,000 square yards of plain cement concrete pavement were laid on Federal-aid projects at an average cost of $1.78 per square yard. Five and one-half million square yards of reinforced concrete pavement were laid on Federal-aid projects at an average cost of $2.16 per square yard. This gives a weighted average for all Federal-aid concrete pavements of approximately $1.90 per square yard. On the assumption that these unit prices are representative of prices for concrete pavements built by State and local authorities and that the proportions of plain and reinforced pavements for the total mileage built are about the same as for the Federal-aid mileage, the price of $1.90 per square yard will be used in the detailed analysis of costs.

The distribution of this unit cost in respect to the various items of expense is shown in table 16. The percentages have been calculated from data collected in cost studies. On individual projects, costs and their distribution will vary considerably from these figures, but the table is believed to be representative of average conditions.

TABLE 16.—*Distribution of average cost of cement concrete pavements on Federal-aid projects in 1930 of $1.90 per square yard* [1]

	Cost	Percent
Cement	$0.435	23
Transportation of cement [2]	.135	7
Total	.570	30
Coarse aggregate	.190	10
Transportation of coarse aggregate [2]	.190	10
Total	.380	20
Fine aggregate	.075	4
Transportation of fine aggregate [2]	.095	5
Total	.170	9
Cost and transportation of cement and aggregate	1.120	59
Reinforcing steel, joint material, etc	.115	6
Depreciation of equipment	.170	9
Labor and supervision	.210	11
Batch delivery (labor and equipment)	.135	7
Overhead, interest, bond, cost of set-up, etc	.075	4
Return to contractor, including salary	.075	4
Total	1.900	100

[1] Based on bid prices and includes cost of fine grading.
[2] Transportation to batching plant.

During 1930, approximately 10,000 miles of portland cement concrete pavements were built on rural highways. Assuming a pavement width of 20 feet, the cost per mile was approximately $22,500 and the total

cost was $225,000,000. The percentage distribution of this total expenditure is shown in figure 4.

The analysis shows that the cost of cement and aggregates delivered to the contractor's plant is 59 percent of the pavement cost, and that 22 percent of this total pavement cost is for the transportation of materials from the source of supply to the batching plant on the project. Transportation charges constitute 37 percent of the cost of these materials.

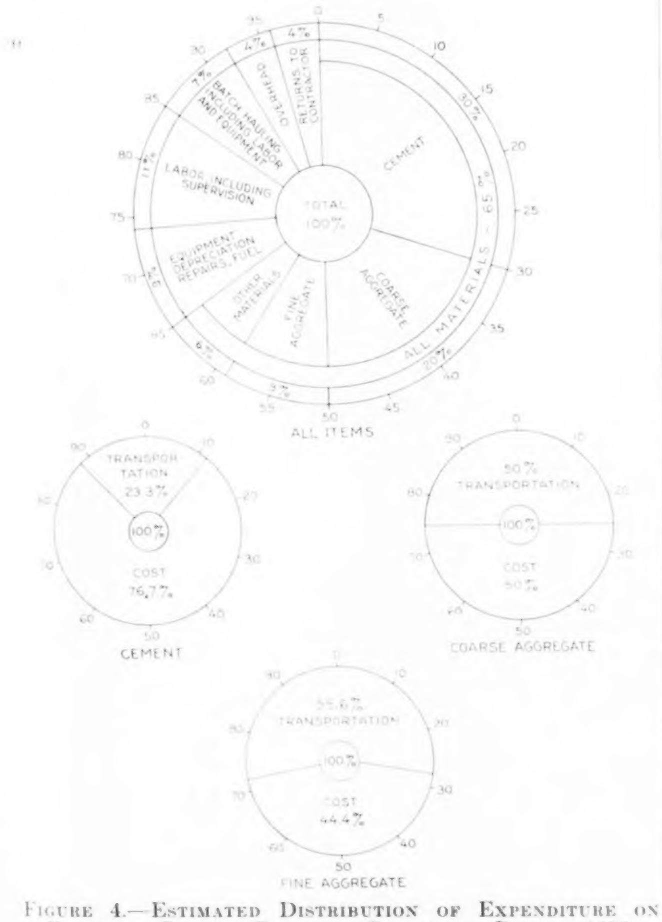


FIGURE 4.—ESTIMATED DISTRIBUTION OF EXPENDITURE ON PORTLAND CEMENT CONCRETE PAVEMENTS DURING 1930.

IF METHODS OF MIXING AND PLACING CAN BE IMPROVED, LESS CEMENT WILL BE REQUIRED

The largest item of expense is for cement the cost of which, delivered to the project, is about 30 percent of the total pavement cost. The cement factors used on the 34 projects studied during 1929 and 1930 varied from 1.23 to 2.10 barrels of cement per cubic yard of concrete. The possibility of reducing the amount of cement used without reducing the quality of the pavement is dependent on several factors, one of which is the uniformity with which the ingredients are distributed throughout the mass of concrete. Available information indicates that the present method of combining ingredients does not produce concrete in which these ingredients are uniformly distributed throughout the mass.

Analyses of samples removed from concrete after it has been spread on the subgrade show that variation in the amount of any one ingredient from one part of a batch to another part is often as high as 20 or 30 per-

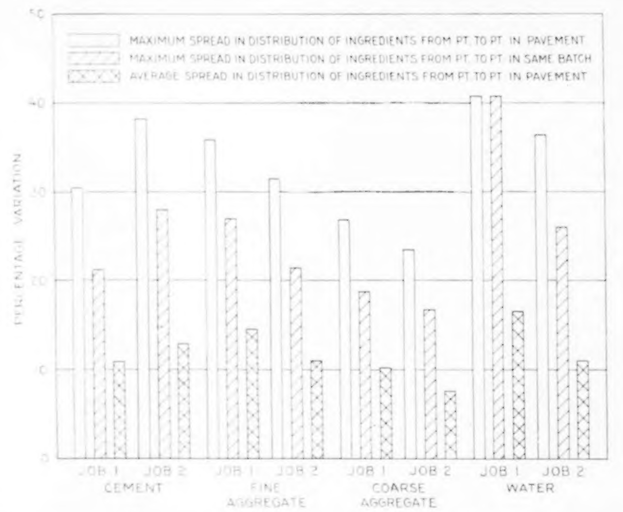


FIGURE 5.—VARIATION IN DISTRIBUTION OF INGREDIENTS OF CONCRETE AS MIXED IN STANDARD PAVERS.

cent. One point in the batch may contain 10 or 15 percent more of an ingredient than the average for the batch while another point may be deficient by a similar amount. Percentage differences or "spreads" between points as high as 30 percent are not uncommon. The average spread in the proportion of any 1 of the 4 ingredients is about 10 percent. This lack of uniformity in the distribution of the ingredients no doubt accounts, to a large extent, for the wide variations that are found in the compressive strengths of cores removed from concrete pavements. Figure 5 shows the percentage spreads in materials on two different projects. These are typical examples of the lack of uniformity resulting from the present method of mixing concrete. Could the mixing be improved so that the ingredients would be uniformly distributed in the pavement, the cement content probably could be reduced, resulting both in a reduction in the cost of this material and a probable increase in the quality of the pavement.

Methods of manipulation must be considered in fixing the water and cement content of concrete. Present methods of placing concrete require rather wet mixes. It is generally accepted that the strength of concrete varies inversely with the ratio of the water to the cement. If methods of manipulation can be improved so that considerably drier concrete can be placed satisfactorily, a reduction in the amount of cement used should result.

The cost of reinforcing steel, material for joints, and other minor materials, averages 6 percent of the pavement cost. The cost varies considerably on different projects. Some States use heavy, double reinforcing while other States use no reinforcing. The spacing of transverse joints likewise varies between wide limits. Some States use no transverse joints while others space joints as close as 20 or 30 feet. For the 34 projects analyzed the transverse joints per square yard of pavement varied from none to 0.45 lineal foot.

EQUIPMENT COSTS ANALYZED

The cost of equipment is about 9 percent of the pavement cost. The most logical way to reduce this cost is to increase the efficiency with which equipment is operated by using a greater percentage of available working time. Annual or monthly expense for equipment is nearly constant except for field repairs, fuel, and lubri-

cants. Costs do not vary materially with production obtained. The unit cost for depreciation, overhauling, major repairs, interest, taxes, storage, and insurance therefore varies almost inversely with the rate of production.

The unit cost for field repairs, fuel, and lubricants can be expected to vary nearly directly with the rate of production. There is no accurate method of determining equipment expense. The care that a piece of equipment receives is important in affecting its life. Equipment obsolescence affects costs. In the absence of a definite method of determining equipment expense, an approximation of the average daily equipment cost for the country as a whole is given in table 17. The figures shown in this table may not be applicable to every paving organization but they are suitable for use in general comparisons.

The figures in table 17 are based on an assumption that the average length of a construction season is 8 months (from Mar. 1 to Nov. 1). There are 245 days in this period of which 35 are Sundays and 3 are holidays. It is reasonable to assume that during an 8-month construction season the average paving contractor will have two projects. This necessitates a move from one project to the other. Allowing 12 working days for this move, 195 days or 24 days per month are available for operation. Table 12 shows that on the 34 projects analyzed the major unavoidable delays were as follows:

UNAVOIDABLE MAJOR DELAYS

Cause of delay:	*Percentage of available working time*
Rain	12. 1
Wet subgrade	9. 4
Cold weather, snow	4. 6
Moving equipment about project	4. 0
Lack of prepared subgrade	2. 3
Lack of materials	1. 4
Paver trouble, mechanical	1. 0
Inadequate water supply	. 4
Miscellaneous	2. 1
Total	37. 3

Thirty-seven percent of the total available working time was lost through delays of 15 minutes or over, delays that the contractor could not have been expected to anticipate and prevent. Delays from adverse weather conditions, wet subgrade, and moving the equipment about the project amount to 30 percent of available working time. Such delays generally last from one-half day to several days. During these periods the outfit usually does not operate, and the personnel, with the exception of straight-time men, is not on the job and does not draw pay.

The remaining delays, which amount to 7 percent of available working time, may or may not be of sufficient duration to shut down the outfit and stop production. In this discussion such delays will be considered as occurring during periods when the entire personnel is on the job and drawing pay. The possible

TABLE 17.—*Estimated equipment costs* [1]

Equipment	Number and capacity	Average annual expense as a percentage of first cost, exclusive of field repairs				Average use per year	Expense per working month	Application of schedule to specific prices		Estimated daily equipment cost for all items except field repairs, fuel, grease, and oil [2]	Estimated daily cost of fuel, oil, grease, and field repair	Total estimated daily equipment cost including all items
		Depreciation	Overhauling, major repairs, painting	Interest, taxes, storage, insurance	Total ownership expense			Price	Expense per working month			
Fine grading:		*Percent*	*Percent*	*Percent*	*Percent*	*Months*	*Percent*					
Blade graders	1, 10 foot	20	20	11	51	8	6. 4	$1, 250	$80	$4. 70	$0. 50	$5. 20
Tractors	1, 60 horsepower	20	15	11	46	8	5. 7	4, 300	245	14. 41	6. 90	21. 31
Scarifiers	1	25	20	11	56	8	7. 0	1, 000	70	4. 12		4. 12
Subgraders (form)	1	25	20	11	56	8	7. 0	1, 075	75	4. 41		4. 41
Subgrade planers	1	25	20	11	56	8	7. 0	500	35	2. 06		2. 06
Rollers	1, 6-ton	14	12	11	37	8	4. 6	2, 900	134	7. 88	3. 00	10. 88
Fresnos	2, 3-foot	33	20	11	64	8	8. 0	50	4	. 29		. 29
Fresno teams	2, 2-horse	10		6	16	12	1. 3	600	8	. 47	[3] 5. 30	5. 77
Handling and setting forms:												
Forms	4,300 feet	25	20	11	56	8	7. 0	3, 440	241	14. 17		14. 17
Teams	1, 2-horse	10		6	16	12	1. 3	300	4	. 24	[3] 2. 65	2. 89
Form trenchers	1	25	20	11	56	8	7. 0	1, 800	126	7. 41	1. 50	8. 91
Handling materials:												
Crane (15 ton)	1, 1 cubic yard	17	10	11	38	8	4. 8	14, 000	672	39. 53	13. 50	53. 03
Batcher plant (complete)	1, 70 cubic yards	20	15	11	46	8	5. 7	2, 785	159	9. 34		9. 34
Cement house	1				75	8	9. 4	500	47	2. 76		2. 76
Pumps (water)	1	25	20	11	56	8	7. 0	1, 700	119	7. 00	3. 00	10. 00
Pipeline, 2½-inch	25,000 feet	25	5	11	41	8	5. 1	6, 425	328	19. 30		19. 30
Hose, 1½-inch	250 feet				50	8	6. 3	150	9	. 53		. 53
Truck (service)	1	36	14	11	61	8	7. 6	1, 150	88	5. 17	2. 50	7. 67
Hauling batches:												
Trucks [4]												
Turntable	1	25	15	11	51	8	6. 4	1, 000	64	3. 76		3. 76
Mixing: Paver, 27-E	1	25	15	11	51	8	6. 4	8, 800	564	33. 18	8. 50	41. 68
Finishing:												
Finishing machine	1	25	15	11	51	8	6. 4	3, 000	192	11. 29	2. 00	13. 29
Flaots	2				100	8	12. 5	50	6	. 35		. 35
Belts	2				100	8	12. 5	20	3	. 18		. 18
Bridges (wood)	4				100	8	12. 5	60	8	. 47		. 47
Curing:												
Burlap	1,300 lineal feet				100	8	12. 5	260	33	1. 94		1. 94
Hose, ¾-inch	400 feet				50	8	6. 3	40	3	. 18		. 18
Miscellaneous:												
Small tools					50	8	6. 2	500	31	1. 82		1. 82
Field machine shop tools					50	8	6. 2	500	31	1. 82		1. 82
Supervision: Automobile [5]	1	33	20	11	64	12	5. 3	1, 500	78	4. 59	3. 50	8. 09
Total								59, 655	3, 457	203. 37	52. 85	256. 22

[1] Cost of all items of expense except field repairs, fuel, oil, and grease based on modified Associated General Contractors' equipment ownership schedule.
[2] Based on 17 working days per month.
[3] Animal feed.
[4] Truck costs are variable depending on length of haul, and have been excluded from this analysis.
[5] Automobile used 26 days per month, but monthly cost charged to 17 productive days.

working time will therefore be 70 percent of 195 days, or 136.5 days. This gives 17 possible working days per month during a construction season.

Monthly equipment expense exclusive of field repairs, fuel, and lubricants is prorated over the 17 working days that equipment can be actually operated under average conditions. Daily costs for field repairs, fuel, and lubricants are based on observations made during the time studies and are estimates only. The total average daily equipment expense as derived by this method of estimating is $256. The portion of this expense regarded as constant regardless of production is $203.

The production studies show that the average contractor operates major equipment with an efficiency of 78 percent. With a 69-second mixing time and a batch of 27 cubic feet this means an average production of 300 cubic yards of concrete per 9-hour day, or a fixed unit cost for equipment of 85 cents per cubic yard. With an efficiency of 90 percent this fixed equipment charge would be 74 cents per cubic yard.

LABOR COSTS DISCUSSED

The cost of labor, including supervision, is 11 percent of the pavement cost. The number of men employed is usually that necessary to handle maximum paver production and remains relatively constant. It does not fluctuate as the hourly or daily rate of production fluctuates because of delays. The daily labor cost can therefore be considered as an almost constant amount. As production decreases, the unit cost for labor increases.

To determine daily labor cost it is first necessary to consider the basis of payment of personnel and that part of the personnel which is on the straight-time pay roll. Although there is some variation in the number of men carried on the straight-time pay roll by different paving organizations, the straight-time men are usually a superintendent, a timekeeper, four foremen, a crane operator, a paver operator, and a mechanic. Some common labor is also employed during periods of nonproduction and appears on the straight-time pay roll. However, such labor is affected by job conditions and therefore is omitted in this discussion. The superintendent is usually paid on a monthly or yearly basis. The other men on the straight-time pay roll are generally kept working on the job during periods of nonproduction and are usually paid on a weekly basis for all time except Sundays and possibly holidays. During an 8-month construction season the superintendent will usually be paid for 245 days. The remaining straight-time workmen will usually be paid for 245 days less 35 Sundays and 3 holidays, or 207 days. It is again assumed that there will be 136 productive days during the construction season on which the remaining personnel will be paid. Table 18 gives the approximate daily cost for labor per day of actual construction, assuming an average working day of 9 hours and wage rates which are averages for the country as a whole. Payments made to straight-time men are distributed among the productive days.

With an over-all efficiency of operation of major equipment of 78 percent and a daily pay-roll cost of $334.23, the unit labor cost is $1.11 per cubic yard. With an over-all efficiency of operation of 90 percent the unit cost would be 96 cents.

TABLE 18.—*Pay-roll costs on an assumed typical project for each productive day. Based on 136 productive days per season*

Position	Number	Daily rate	Days for which pay is received during season	Nonproductive days during season for which pay is received	Total cost of nonproductive time	Prorated cost of nonproductive time to each productive day	Daily cost of productive time	Total cost for each productive day
Superintendent	1	$12.00	245	109	$1,308	$9.62	$12.00	$21.62
Timekeeper	1	5.00	207	71	355	2.61	5.00	7.61
Foremen	4	6.00	207	71	1,704	12.53	24.00	36.53
Crane operator	1	9.00	207	71	639	4.69	9.00	13.69
Paver operator	1	7.00	207	71	497	3.65	7.00	10.65
Mechanic	1	6.00	207	71	426	3.13	6.00	9.13
Other machine operators	7	5.00	136	0	0	0	35.00	35.00
Semiskilled and heavy common labor	18	4.50	136	0	0	0	81.00	81.00
Ordinary common labor	34	3.50	136	0	0	0	119.00	119.00
Total	68				4,929	36.23	297.50	334.23

The cost for labor and equipment on concrete pavement construction during 1930 is estimated to have been $44,600,000. Had the general over-all efficiency of operation of major equipment been 90 percent instead of what it actually was it is reasonable to suppose that the total labor and equipment costs would have been reduced by at least $4,000,000. It is to the advantage of both contractors and engineers that concrete construction be carried on with a high degree of efficiency. Efficiency is advantageous to the contractor in his efforts to meet competition. A competent superintendent, invested with the necessary authority, is invaluable to him. Efficiency works to the advantage of the engineer as it is his duty to see that the general public receives the greatest value in both quality and quantity for expenditure for concrete pavements.

HAULING COSTS AN IMPORTANT ELEMENT

An estimate for the cost of equipment and personnel connected with batch hauling, that is, transporting the batches containing aggregates and cement from the batching plant to the paver, has not been included in the preceding analysis. The cost of batch hauling is estimated to be 7 percent of the pavement cost. This figure is based on average haul and costs on the projects studied. Transporting batches from the batching plant to the paver on the road is an operation separate from that of paving. It is synchronized with the paving operation in that a definite number of trucks is required to furnish the paver with the maximum number of batches that it can mix per hour. The hauling equipment on the average project is usually operated with less efficiency than is the major paving equipment. This is especially true where the hauling is sublet, in which cases the equipment is often owned and operated by several individuals and is not directly supervised.

The daily cost of truck operation is not affected by the amount of work done except in the items of field repairs, fuel, and lubricants. The cost for the truck driver will be the same regardless of the number of batches hauled. The daily cost of operating a hauling unit can be considered as almost a fixed charge. The unit cost of hauling batches will be determined by the number of batches that the truck can deliver per day, and this in turn will be determined by the following items:

1. Haul distance.
2. Condition of hauling road.
3. Efficiency of truck operation.
4. Number of trucks in excess of those required to match maximum paver production.
5. Efficiency of paver operation.
6. Length of time required for loading, turning, backing, passing through plant yard, dumping batch, waiting to dump first batch of multiple batch truck, time interval between the dumping of batches, and necessary delays.

Fluctuating production of the paver increases the unit hauling cost by causing delays to the hauling units. On the other hand an insufficient supply of hauling units or faulty operation causes delays to the paving organization. Table 13 shows that one-half of the minor avoidable delays to major equipment were due to these two causes and amount to 7.6 percent of the time that the major equipment was actually operating. Harmony between the paving operations and the hauling operations requires that the paving organization should operate at a uniform rate; that the hauling equipment be adequate for the rate of paver production; and that the hauling equipment be operated at a steady pace without interruption.

The investment in hauling equipment may be even greater than the combined investments in all the other equipment. Inefficient operation of hauling units may increase costs greatly.

The cost of overhead, interest, bonds, set-up charges, etc., is estimated at 4 percent of the bid price, and the return to the contractor in the form of salary and profit, after all other cost items have been met, is also placed at 4 percent. These items are more or less intangible and the percentages shown are merely estimates made for the purpose of this analysis. The true cost may be a few percent either way from the percentages shown, but the distribution of the remaining cost will not be materially changed from the figures shown in this cost analysis.

TABLE 19.—*Examples of job efficiency between 1923 and 1928*

Project no.	Year	Total available working time during study	Unavoidable delays	Avoidable delays	Time paver operated at full efficiency	Time paver could have operated at full efficiency had avoidable delays been eliminated	Actual efficiency of operation
		Hours	*Hours*	*Hours*	*Hours*	*Hours*	*Percent*
1	1923	740.0	113.0	301.0	326.0	627.0	52.0
2	1924	222.0	63.8	71.2	87.0	158.2	55.0
3	1924	163.0	42.0	56.1	64.9	121.0	53.5
4	1924	146.0	36.5	40.0	69.5	109.5	63.5
5	1925	210.0	73.5	79.9	56.6	136.5	41.5
6	1925	477.5	157.8	120.2	199.5	319.7	62.5
7	1926	1,164.5	429.1	358.9	376.5	735.4	51.2
8	1927	1,143.3	197.3	465.1	480.9	946.0	50.9
9	1927	520.0	82.9	147.6	289.5	437.1	66.2
10	1928	512.0	90.0	182.3	239.7	422.0	56.8
Total		5,298.3	1,285.9	1,822.3	2,190.1	4,012.4	54.6

TABLE 20.—*Summary of weekly time losses on a project operated efficiently*

[Study made in 1931]

Week ending—	Batches produced	Total available working time	Major delays			Minor delays			Total of all delays
			Class A	Class B	Total	Class A	Class B	Total	
		Hours	*Hours*	*Hours*	*Hours*	*Hours*	*Hours*	*Hours*	*Hours*
June 27	1,986	65.50	12.50	0.25	12.75	1.84	2.97	4.81	17.56
July 4	1,635	43.00	1.47	.25	1.72	.88	.89	1.77	3.49
July 11	1,447	65.35	29.21		29.21	.04	1.17	1.21	30.42
July 18	1,394	60.75	23.97		23.97	1.48	1.63	3.11	27.08
July 25	1,676	60.50	13.83	[1] 3.50	17.33	1.03	1.64	2.67	20.00
August 1	2,163	60.25	7.01	.25	7.26	.25	.34	.59	7.85
August 8	2,390	60.66	1.30	.75	2.05	.43	.40	.83	2.88
August 15	1,435	60.63	24.62		24.62	.89	.43	1.32	25.94
August 22	2,425	60.30	1.02		1.02	.30	.49	.79	1.81
Total	16,551	536.94	114.93	5.00	119.93	7.14	9.96	17.10	137.03

Week ending—	Time major equipment operated at 100 percent efficiency	Total of all class B delays	Possible operating time eliminating class B delays	Possible batches with class B delays eliminated	Over-all efficiency
	Hours	*Hours*	*Hours*		*Percent*
June 27	47.94	3.22	51.16	2,119	93.5
July 4	39.51	1.14	40.65	1,685	97.0
July 11	34.93	1.17	36.10	1,495	96.6
July 18	33.67	1.63	35.30	1,460	95.4
July 25	40.50	5.14	45.64	1,890	88.7
August 1	52.40	.59	52.99	2,190	98.9
August 8	57.78	1.15	58.93	2,438	98.1
August 15	34.69	.43	35.12	1,451	98.7
August 22	58.49	.49	58.98	2,445	99.2
Total	399.91	14.96	414.87	17,173	96.4

[1] Time required to remove hardened batch of concrete from drum.

TABLE 21.—*Summary of time losses on project reported in table 20 and their effect on production*

[Total available working time, 536.9 hours. Estimated production, 16,551 batches]

TOTAL MAJOR DELAYS OCCURRING DURING AVAILABLE WORKING TIME

Cause of delay	Class A		Class B	
	Hours	*Percent*	*Hours*	*Percent*
Rain	39.69	7.4		
Moving mixer	25.53	4.7		
Wet subgrade	18.74	3.5		
Pouring concrete gutter	12.75	2.4		
Mixer trouble, mechanical	8.56	1.6		
Pouring headwalls	5.89	1.1		
Removing concrete from drum			3.50	0.7
Batcher trouble	1.55	.3		
Preparing subgrade			.75	.1
Skip blocked by traffic	.62	.1		
Water supply trouble	.45	.1		
Truck operation	.40	.1		
Truck shortage	.25	.0		
Wreck	.25	.0		
Miscellaneous	.25	.1	.25	.0
Late start			.50	.1
Total	114.93	21.4	5.00	.9

TOTAL MINOR DELAYS OCCURRING DURING TIME OF ACTUAL OPERATION

Cause of delay	Class A Hours	Class A Percent	Class B Hours	Class B Percent
Truck operation	2.27	0.5	2.89	0.7
Mixer trouble, mechanical	1.17	.3	2.15	.5
Water supply	1.42	.3	.21	.0
Truck shortage	.30	.1	1.17	.3
Mixer operation			1.21	.3
Handling cement			1.05	.3
Placing reinforcing steel	.17	.0	.65	.2
Wet subgrade	.76	.2		
Rain	.58	.1		
Preparing subgrade			.35	.1
Miscellaneous	.12	.0	.15	.0
Setting expansion joint	.13	.0	.10	.0
Skip blocked by traffic	.11	.0		
Truck trouble, mechanical	.11	.1		
Dumping			.03	.0
Total	7.14	1.6	9.96	2.4

Total major delays 119.9 hours or 22.3 percent of working time.
Total minor delays 17.1 hours or 4 percent of working time.
Possible operating time with all avoidable delays eliminated 414.9 hours.
With all avoidable delays eliminated production would have been 17,170 batches.
Over-all efficiency of operation of major equipment 96.4 percent.

EFFICIENCY IN CONSTRUCTION GREATLY IMPROVED IN RECENT YEARS

When production studies of highway construction were started in 1923 the efficiency with which concrete paving was laid was much less than it is today. Very little attention was given to attaining maximum paver production or to the full use of available working time. In recent years, there has been a gradual increase in the efficient use of working time. Table 19 indicates that trend.

The 10 projects listed in table 19 were studied in the years shown and are representative of supervision better than the average. With few exceptions the projects selected for efficiency studies were each several miles in length and all were constructed with standard paving equipment. The projects were located in five different States. Project no. 2 was in one of the central States. The contractor's organization on project 2 had the reputation of being the most efficient in the State, yet the major equipment was operated with an efficiency of only 55 percent.

In contrast with the rates of efficiency shown in table 19 for years prior to 1929, 10 of the projects studied in recent years (table 11), each using a single paver, were operated with an over-all efficiency of more than 85 percent and 6 projects were operated with an efficiency of 90 percent or more.

An example of the high efficiency that can be maintained in concrete paving is given in table 20. This is a summary of production studies made on a paving project in an eastern State during a period of 9 weeks in the summer of 1931. The drop in efficiency in the fifth week was caused by the paver operator's negligence in allowing a batch of concrete to harden in the mixer while the motor was being repaired. Table 21 contains a summary for the 9 weeks of operation and shows the cause and extent of all delays.

Efficient use of available working time has steadily increased. This increase has had a favorable effect on unit costs. It is generally recognized that this increase in the rate of production has had no adverse effect on the quality of pavements.

The cost of labor and equipment, however, is only a part of the cost of a concrete pavement. Improvements in the methods and equipment used in the production of paving materials as well as in the production of finished surfaces, together with more definite information concerning the design of concrete mixtures as developed through research will increase both the efficiency of concrete pavement construction and the value received by the public per dollar of pavement expenditure.

STATE GASOLINE TAXES, 1933

[Compiled for calendar year from reports and records of State authorities]

State	Gross tax assessed prior to deduction of refund	Exemption refund (deducted from gross tax)	Net tax earning on motor vehicle fuel [1] [2]	Other receipts, under tax law (licenses, etc.)	Grand total earning (tax and other receipts)	Disposition of grand total earning, according to law [2]						Tax rate, 1933			Gasoline, or other fuel for motor vehicles, taxed	
						Collection and administration cost [3]	Construction and maintenance on rural roads		State and county road bond payments [5]	On city streets	Other than highway purposes	Cents per gallon		Date of rate change	Net gallons taxes	Percent change [6]
							State highways [4]	Local roads [4]				Jan. 1	Dec. 31			
Alabama	$8,033,141		$8,033,141	$1	$8,033,142	$17,671	$2,508,119	$4,001,673	$1,505,679			6	6		133,885,679	−1.86
Arizona	3,226,831	$547,799	2,679,032	225	2,679,257	(7)	1,607,644	924,060			[8] $147,553	5	5	[9] Mar. 2	53,580,633	−7.63
Arkansas	6,543,025	553,596	5,989,429	8,861	5,998,290	220,147	1,376,222	639,566	[10] 3,446,153		[11] 316,202	6	[12] 6		114,791,930	33.35
California	38,774,555	3,557,393	35,217,162		35,217,162	[13] 82,134	22,817,380	12,036,373		$265,142	[14] 16,133	3	3		1,173,905,406	−2.52
Colorado	6,012,639	687,643	5,324,996		5,324,996	61,234	3,684,633	1,421,216		157,913		4	4		133,124,908	−2.64
Connecticut	4,962,513	150,883	4,811,630	45,394	4,857,024	(15)	4,857,024					2	2		240,581,476	2.71
Delaware	1,177,853	50,523	1,127,330	2,247	1,129,577	(16)	850,873		[17] 278,704			3	3		37,577,673	3.41
Florida	14,249,308		14,249,308	43,565	14,292,873	21,079	6,106,846		[18] 6,106,846		[19] 2,058,102	7	7		203,561,549	−1.79
Georgia	12,634,513		12,634,513		12,634,513	63,173	8,380,894	2,095,223			[20] 2,095,223	6	6		210,575,216	5.83
Idaho	2,535,966	253,596	2,282,370	796	2,283,166	11,868	2,055,048		[21] 216,250			5	5		45,647,396	0.20
Illinois	29,129,584	1,296,573	27,833,011		27,833,011	133,397	18,466,409	5,468,109			[22] 3,765,096	3	3		927,767,039	−3.20
Indiana	17,490,596	1,207,394	16,283,202	5,444	16,288,646	71,077	8,108,784	6,487,028		1,621,757		4	4		407,080,056	−2.73
Iowa	10,667,048	1,294,705	9,372,343		9,372,343	59,593	3,374,705	3,838,045	[23] 2,100,000			3	3		312,411,442	4.48
Kansas	10,258,397	2,526,578	7,731,819	39,550	7,771,369	[24] 179,454	5,779,180	1,800,000			[25] 12,735	3	3		257,727,287	4.20
Kentucky	8,314,659		8,314,659	1,358	8,316,017	48,246	8,267,771					5	5		166,293,182	1.36
Louisiana	8,155,482	46	8,155,436		8,155,436	62,000	2,361,222		4,100,825		[26] 1,631,389	5	[27] 5		163,138,863	−1.73
Maine	4,265,446	185,075	4,080,371	[28] 46,269	4,126,640	16,074	2,055,283	2,055,283				4	[29] 4		102,009,277	−3.00
Maryland	7,588,176	380,427	7,207,749		7,207,749	17,300	5,384,741	7,423		1,672,965	[30] 125,320	4	4		180,193,738	−3.90
Massachusetts	16,709,793	332,441	16,377,352		16,377,352	50,000	6,517,673	2,073,592	313,628		[31] 7,422,459	3	3		545,911,726	−0.86
Michigan	20,460,257	1,001,799	19,458,458	26,862	19,485,320	109,502	2,303,607	14,045,349	3,000,000		[32] 26,862	3	3		648,615,259	−4.76
Minnesota	11,326,991	1,312,134	10,014,857	[33] 198,779	10,213,636	(34)	6,425,314	3,600,000			[35] 188,322	3	3		333,828,560	0.14
Mississippi	6,721,859	920,134	5,801,725	[36] 299,223	6,100,948	23,311	2,874,459	2,573,341	495,192		[37] 134,645	6	6		96,695,407	−0.04
Missouri	9,317,610	236,475	9,081,135		9,081,135	55,934	9,025,201					2	2		454,056,751	1.47
Montana	3,415,209	663,906	2,751,303		2,751,303	31,512	2,650,591		69,200			5	5		55,026,065	2.27
Nebraska	7,792,812	86,551	7,706,261		7,706,261	56,411	5,095,848	2,298,602		255,400		4	4		192,656,526	−1.32
Nevada	825,176	129,523	695,653		695,653	(38)	695,653					4	4		17,391,339	−4.33
New Hampshire	2,418,103	68,254	2,349,849		2,349,849	(39)	1,762,387		587,462			4	4		58,746,216	−10.95
New Jersey	20,963,377	4,565,991	16,397,386	[40] 73,261	16,470,647	52,450	2,438,310	6,396,475	2,296,000		[41] 5,287,412	3	3		546,579,541	−1.32
New Mexico	2,430,319	164,809	2,265,510	16,382	2,281,892	33,935	898,005		1,349,952			5	5		45,310,187	3.34
New York	44,425,847	1,081,152	43,344,695	48,251	43,392,946	[42] 140,780	21,646,458	5,761,145		1,440,286	[43] 14,404,277	3	[44] 3		1,444,837,830	−2.71
North Carolina	14,974,123	204,521	14,769,602	3,680	14,773,282	6,099	4,952,913	2,931,286	[45] 6,540,385		[46] 342,599	6	6		246,160,036	6.23
North Dakota	2,787,728	863,777	1,923,951	879	1,924,830	25,000	1,266,553	633,277				3	3		64,131,714	4.81
Ohio	35,740,548	1,800,567	33,939,981		33,939,981	153,028	15,426,893	7,640,678		5,730,509	[47] 4,988,873	4	4		838,020,083	−2.18
Oklahoma	10,064,685		10,064,685	13,960	10,078,645	64,847	4,994,942	2,419,183			[48] 2,599,673	4	4		251,617,119	4.18
Oregon	7,282,245	938,354	6,343,891		6,343,891	20,616	4,604,599		[17] 1,718,676			4	5	June 9	135,819,611	−3.03
Pennsylvania	31,353,940	614,823	30,739,117	[49] 320,261	31,059,378	[50] 349,547	22,141,876	5,110,747	[17] 3,457,208			3	3		1,024,637,243	1.48
Rhode Island	2,004,038	123,066	1,880,972	3,710	1,884,682	(51)	1,246,567		302,000		[52] 336,115	2	2		94,048,613	1.45
South Carolina	6,716,510	37,184	6,679,326		6,679,326	(53)	1,924,367	1,113,221	[54] 3,641,738			6	6		111,322,101	7.30
South Dakota	3,849,544	[55] 503,529	[56] 3,346,015		3,346,015	41,399	1,900,047				[57] 1,404,569	4	4		78,382,211	5.80
Tennessee	12,979,882		12,979,882		12,979,882	154,721	3,481,115	[58] 3,847,548	[59] 5,496,498			7	7		185,426,887	6.52
Texas	31,430,379	2,951,029	28,479,350		28,479,350	201,122	14,139,114		[18] 7,069,557		[60] 7,069,557	4	4		711,983,752	5.23
Utah	2,189,065	67	2,188,998	716	2,189,714	4,241	2,185,473		(61)			4	4		54,724,960	0.79
Vermont	1,766,152		1,766,152		1,766,152		1,321,102	230,000	215,050			4	4		44,153,789	−5.79
Virginia	11,679,511	597,471	11,082,040		11,082,040	25,000	7,739,928	3,317,112				5	5		221,640,804	2.52
Washington	11,852,828	989,614	10,863,214		10,863,214	22,688	7,971,469	[62] 2,000,000			[63] 869,057	5	5		217,264,282	−1.66
West Virginia	5,149,595	229,931	4,919,664	8,064	4,927,728	11,506	1,759,477		3,156,745			4	4		122,991,600	−0.45
Wisconsin	16,599,578	1,430,152	15,169,426		15,169,426	29,705	9,255,610	[64] 3,992,249	[18] 1,284,000	107,862	[19] 500,000	4	4		379,235,644	1.48
Wyoming	1,405,415		1,405,415		1,405,415		829,042	351,354	[17] 225,019			4	4		35,135,367	−0.90
District of Columbia	2,097,257	14,911	2,082,346		2,082,346					2,082,346		2	2		104,117,297	2.30
Total			518,195,712	1,207,738	519,403,450	2,727,801	277,517,371	111,109,158	58,972,767	13,334,180	55,742,173	Weighted average rate, 3.65 cents			14,224,321,270	−0.18

[1] Net gasoline tax earned after deduction of refunds allowed by law.

[2] Legislation enacted in several States authorizes the diversion of gasoline tax revenue to purposes other than for highways after such funds have been transferred by the collecting agency presumably for road purposes. In several such cases the reports of collecting agencies as given here indicate the initial distribution and not the final distribution. The County Commissioners of Florida counties of 4,135 to 4,300 population are authorized to transfer surplus money of road and bridge funds derived from the gasoline tax to courthouse and jail funds. Gilchrist County transferred $6,811. Legislation in Michigan provided possible contingent use of gasoline revenue for payment of calamity or welfare relief bonds. Allocations of gasoline tax funds to counties and cities in Ohio may be expended for poor relief.

[3] Many States pay collection cost from other State funds, and such are noted. Administration cost includes balances allocated to reserve funds for administrative purposes, and amounts are noted.

[4] Since this table covers the calendar year earnings, but not the actual collections during the year, these columns are not comparable with similar columns in tables F-1 and F-4 which cover different periods fixed by State and local agencies; also certain funds are allocated to bond payments shown in next column.

[5] For State highway bonds, except as noted.

[6] Shows percentage increase or decrease compared to net gallons reported in previous year.

[7] Approximately $16,000 paid from State highway budget.

[8] Relief fund, 1/10 of net motor fuel tax after June 30, 1933.

[9] On February 1 tax reverted to 4 cents and on date shown changed back to 5 cents.

[10] Includes $2,692,323 assignable to county bond payments.

[11] Transfer to State Charity fund.

[12] Tax rates of 2, 4, and 5 cents allowed at State borders.

[13] Consists of $61,099 to transportation division of State board of equalization and $21,035 to Controller refund division.

[14] Includes $14,297 for payment of claim and $1,836 for employees retirement fund.

[15] Cost of approximately $16,000 paid from motor vehicle license receipts.

[16] Paid from State general fund.

[17] Bond payments from combined fund of gasoline taxes and motor vehicle fees and pro-rated between them.

[18] Payments on county road bonds.

[19] To State general revenue fund.

[20] To an equalization fund for public schools.

[21] Payments on State highway treasury notes.

[22] Relief fund payments made from fund formerly apportioned to local roads.

[23] Payments on county bonds for State roads; obligations assumed by State.

[24] Law effective May 1, 1933 allowed 3 percent of net gasoline tax receipts for collection costs: $7,500 from State general fund was used during first six months.

[25] To general funds (State, $1,607 and counties, $11,128).

[26] $815,694 for public schools, $815,695 for ports of New Orleans and Lake Charles harbor boards of commissioners.

[27] Rate of 4 cents permitted on 150,717 gallons near border.

[28] Includes receipts from 1 cent tax on gasoline not used in motor vehicles.

[29] Tax refund of 3 cents allowed for use other than in motor vehicles.

[30] $75,000 to conservation department; $48,000 for approaches to ferries, and $2,320 for protest fees.

[31] To unemployment relief fund, and other nonhighway purposes.

[32] For aeronautic fund $22,677 and $4,185 to State general fund.

[33] Includes inspection fees of 2 cents per 50 gallons.

[34] Paid by State appropriation of $13,000.

[35] Includes $172,909 cost of gasoline inspection and $15,413 to State General fund.

[36] Includes $121,342 from special tax in three counties for financing sea wall.

[37] $121,342 for sea wall, $11,600 for police patrol to enforce motor vehicle law, and $1,703 uncollected checks on closed banks.

[38] $7,500 paid from appropriation to State tax commission.

[39] $4,400 paid from motor vehicle license funds.

[40] Includes $4,802 from 2 cent tax on gasoline used by motor boats.

[41] $5,152,412 to State treasury and $135,000 to Department of Commerce and Navigation.

[42] Includes $50,000 paid to refund reserve.

[43] State general emergency fund from 1 cent extra tax.

[44] Tax rate of 2 cents allowed at border of State.

[45] Includes $360,319 for payments on county bonds.

[46] For police patrol and administration of motor vehicle laws.

[47] Consists of $2,000,000 for State emergency poor relief fund and $2,988, 873 for public school fund.

[48] Consists of $2,262,625 for redemption of State warrants, $237,127 reserve for taxes paid under protest; $99,921 to State general revenue.

[49] Delinquent tax collections.

[50] Includes part of police patrol expenses; amount not reported.

[51] Paid from Motor vehicle fees, $15,558.

[52] To unemployment relief.

[53] Paid from State tax commission appropriation.

[54] Includes $2,712,661 for payments on county bonds.

[55] New law effective during last nine months allows only 2 cent refunds.

[56] This does not correspond to gallons taxed at 4 cent rate due to refunds being at 2 cent rate.

[57] For payments on rural credit bonds.

[58] Includes $183,217 allocated to roads in Great Smoky Mountain Park.

[59] Includes $1,832,166 payments on county bonds and same amount to sinking fund bonds.

[60] For free school fund.

[61] Payments made from motor vehicle fees.

[62] Estimate based on previous year.

[63] Payments on State emergency relief bonds.

[64] Includes $1,133,848 allotted in lieu of personal property tax.

CURRENT STATUS OF U.S. PUBLIC WORKS ROAD CONSTRUCTION
AS PROVIDED IN TITLE II, SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT

CLASS I—PROJECTS ON THE FEDERAL-AID HIGHWAY SYSTEM OUTSIDE OF MUNICIPALITIES

AS OF JUNE 30, 1934

STATE	PUBLIC WORKS FUNDS ASSIGNED FOR CLASS I PROJECTS ON THE FEDERAL AID HIGHWAY SYSTEM	COMPLETED				UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION		BALANCE OF PUBLIC WORKS FUNDS AVAILABLE FOR NEW CLASS I PROJECTS
		Total cost	Public works funds	Regular Federal aid	Mileage	Estimated total cost	Public works funds allotted	Regular Federal aid allotted	Percentage completed	Mileage	Public works funds allotted	Mileage	
Alabama	$ 4,185,067.00	$ 1,596,441.15	$ 880,571.63	$ 715,869.52	61.9	$ 4,625,778.67	$ 2,588,735.13	$ 2,037,043.54	44.5	272.3	$ 233,948.59	21.5	$ 481,811.65
Arizona	3,878,555.11	1,776,203.88	1,735,542.70		131.1	2,598,403.90	2,017,309.12		56.3	153.2	96,740.98	10.7	28,962.31
Arkansas	3,374,167.00	299,964.82	200,126.94	99,837.88	9.5	2,721,289.10	2,328,613.72	392,194.13	59.3	137.0	636,509.29	24.0	208,917.05
California	7,803,677.00	3,837,455.68	2,954,376.75		142.5	6,084,486.14	4,648,401.55		39.6	153.1	191,793.40	15.9	9,105.30
Colorado	3,437,265.00	1,514,031.69	1,500,790.30		96.0	2,059,925.09	1,926,296.72	27,435.65	54.1	54.9			10,177.98
Connecticut	1,404,213.00	31,798.70	31,798.76		.1	1,543,762.06	1,367,983.12	175,778.94	35.6	30.7			4,431.12
Delaware	909,544.00	192,063.14	191,170.71		3.0	698,741.30	698,741.30		63.8	14.7	5,770.00	.3	13,861.99
Florida	2,615,917.00	1,281,060.88	814,074.82	466,986.06	43.7	1,940,045.73	1,603,752.50	335,683.13	64.1	72.3	56,281.75	.7	141,807.93
Georgia	5,045,592.00	1,232,521.05	1,232,521.05		73.6	2,400,287.81	2,400,287.81		41.5	177.5	517,218.84	22.4	895,564.30
Idaho	2,166,858.00	824,604.86	809,780.19		81.8	1,281,245.97	1,239,392.09		47.9	93.5	13,782.82		103,902.90
Illinois	4,585,971.00	50,872.54	50,872.54		.9	2,712,498.06	2,712,498.06		43.1	45.1	1,762,692.49	13.3	59,907.91
Indiana	5,018,921.00					4,405,477.21	4,361,358.38		38.5	119.5	657,562.62	13.2	
Iowa	5,027,830.00	1,057,700.42	1,038,800.00		74.5	4,126,332.98	3,828,980.00		75.4	185.6	140,675.50	9.0	19,374.50
Kansas	5,044,802.00	1,330,234.56	1,329,365.58		206.5	3,917,385.48	3,690,045.12		78.4	191.1	25,391.30	.3	
Kentucky	3,608,332.00	554,103.01	549,646.72		59.6	2,599,204.31	2,590,365.88		69.3	177.9	468,319.40	16.5	
Louisiana	2,914,295.00	222,415.49	222,390.49		9.7	2,913,268.66	2,406,617.66		47.1	67.5	42,623.98	1.5	242,662.87
Maine	1,617,560.00					1,515,228.37	1,479,661.42		56.6	44.0	24,085.44	.2	113,813.14
Maryland	1,782,263.00					801,143.78	791,495.03		48.6	14.9	461,850.00	6.4	528,917.97
Massachusetts	1,101,716.00	289,573.84	212,377.94	69,984.24	6.4	1,123,369.76	807,710.12	315,659.64	64.6	31.4			81,627.94
Michigan	6,113,389.00	80,150.00	80,150.00		1.8	5,177,180.00	5,128,180.00	49,000.00	48.2	243.8	602,366.00	21.0	302,693.00
Minnesota	4,561,011.00	2,488,707.73	2,468,224.86	20,482.87	509.5	1,980,571.21	1,949,360.33	27,500.00	31.3	237.7	143,425.81	12.7	
Mississippi	3,489,337.00	288,524.53	164,210.19	124,314.34	12.8	4,586,982.35	2,481,349.56	2,067,000.85	48.0	235.2	276,070.22	29.1	567,707.03
Missouri	5,237,532.00	895,421.61	695,097.86		43.5	4,390,783.57	4,050,641.00	68,548.60	71.3	149.6	252,033.50	9.3	239,759.64
Montana	4,463,849.00	1,426,917.20	1,246,901.20	100,000.00	93.4	3,541,342.66	3,181,685.86	237,025.83	57.8	270.5	31,988.11	36.2	3,273.83
Nebraska	3,914,481.00	2,122,823.42	1,535,019.12	108,538.00	215.8	2,961,612.91	2,342,867.69		62.8	137.1	35,794.58	9.7	799.61
Nevada	2,909,387.00	1,349,395.18	1,349,395.18		173.0	1,401,020.43	1,401,020.43		31.8	87.1	79,129.02		- 79,842.37
New Hampshire	725,739.00	52,024.43	52,024.43		.3	601,203.04	594,695.63		81.6	10.5			79,018.94
New Jersey	3,099,370.48	66,077.87	66,077.87		6.1	2,756,285.14	2,601,364.13	139,466.42	32.4	36.4	63,503.88	.6	368,424.60
New Mexico	2,896,467.00	1,873,447.55	1,873,447.55		210.5	1,064,442.96	920,513.54	143,929.42	30.1	60.1	41,901.88	3.6	60,604.03
New York	10,271,846.00	510,222.64	410,162.64	43,000.00	8.0	11,280,608.68	9,660,723.68	315,000.00	54.3	230.0	146,997.80	8.4	53,961.88
North Carolina	4,761,147.00	1,037,299.11	714,521.55	322,777.56	103.5	3,310,836.86	2,957,506.09	353,330.77	45.6	465.1	493,815.98	52.9	595,303.38
North Dakota	2,902,224.00	1,050,552.17	1,047,220.19	3,294.32	457.9	1,513,926.68	1,315,248.81	198,677.87	47.0	404.6	473,289.70	138.2	66,465.30
Ohio	7,277,758.00	1,035,375.47	1,030,181.63		27.8	6,437,458.00	6,133,085.00	51,410.00	66.6	159.1	77,878.00	5.0	36,613.37
Oklahoma	4,608,399.00	1,239,211.18	1,237,607.64		101.4	2,931,335.69	2,931,335.69		77.0	196.3	146,968.44	3.1	292,487.23
Oregon	3,053,448.00	1,525,235.01	1,392,618.01	84,317.50	98.9	1,623,500.25	1,484,960.05	128,021.20	45.7	83.2	167,388.02	1.4	8,481.92
Pennsylvania	6,691,194.00	254,788.81	254,421.79		4.4	6,079,556.64	5,895,873.50		44.3	122.0	477,382.67	5.7	63,516.04
Rhode Island	999,354.00	50,178.00	50,178.00		1.1	937,119.34	937,119.34		68.2	19.4	8,732.36		3,324.30
South Carolina	2,729,583.00	263,440.39	263,440.39		24.3	2,039,404.99	2,036,675.37	2,729.62	50.7	186.3	144,097.11	9.0	285,370.13
South Dakota	3,005,739.00	1,086,296.08	1,066,954.69	19,341.39	184.9	1,849,893.45	1,542,099.63	307,793.82	24.1	250.2	143,477.48	41.9	253,207.20
Tennessee	4,246,309.00	1,393,206.06	1,180,143.76	213,062.30	61.5	2,914,317.84	2,553,157.65	361,160.19	54.3	104.0	390,724.63	24.2	122,282.96
Texas	12,122,012.00	4,182,635.90	3,504,691.72		542.4	7,415,941.62	6,877,286.38		44.3	457.5	328,563.97	26.2	1,411,469.93
Utah	2,374,205.00	1,432,093.17	1,429,324.46		146.0	798,151.16	798,151.16		59.5	48.8	68,204.10	.4	78,525.28
Vermont	928,184.00	90,524.22	89,926.93		7.4	847,698.77	818,249.22		59.0	37.4	3,998.46		16,009.39
Virginia	3,708,379.00	1,101,511.50	1,092,037.47	9,474.03	40.2	2,115,368.45	1,992,162.00	119,858.30	54.2	81.4	387,355.78	23.8	236,823.75
Washington	3,057,934.00	884,351.00	879,563.10	3,356.82	44.7	2,095,806.01	2,095,806.01		37.8	60.9	64,640.67	1.4	17,924.22
West Virginia	2,013,405.00	211,470.33	211,470.33		6.7	1,706,233.68	1,700,233.68		73.1	64.9	34,029.42	.7	67,671.57
Wisconsin	4,615,429.00	1,073,457.39	1,063,118.67	1,190.00	50.0	3,553,669.34	3,452,135.29	38,500.00	40.2	174.3	63,174.25	1.4	37,000.79
Wyoming	2,250,663.00	1,005,126.46	882,673.00	80,400.00	177.9	1,423,273.07	1,280,112.23	85,908.57	41.6	272.9	67,031.52	10.2	20,846.25
District of Columbia													
Hawaii	1,683,956.00	122,232.70	109,225.57	12,994.32	6.3	1,626,253.71	1,325,047.89	251,205.82	27.5	26.5	248,693.76	6.8	988.78
TOTALS	186,234,275.59	46,283,442.88	41,194,236.92	2,499,221.15	4,362.8	141,029,652.88	125,926,891.57	8,229,862.31	52.1	6,949.0	10,797,903.52	638.8	8,315,243.58

CURRENT STATUS OF U.S. PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED IN TITLE II, SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT

CLASS II—PROJECTS ON EXTENSIONS OF THE FEDERAL-AID HIGHWAY SYSTEM INTO AND THROUGH MUNICIPALITIES

AS OF JUNE 30, 1934

STATE	PUBLIC WORKS FUNDS ASSIGNED FOR CLASS II PROJECTS IN MUNICIPALITIES	COMPLETED				UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION		BALANCE OF PUBLIC WORKS FUNDS AVAILABLE FOR NEW CLASS II PROJECTS
		Total cost	Public works funds	Regular Federal aid	Mileage	Estimated total cost	Public works funds allotted	Regular Federal aid allotted	Percentage completed	Mileage	Public works funds allotted	Mileage	
Alabama	$ 2,092,533.00	$ 183,974.41	$ 183,974.41		3.1	$ 1,133,335.74	$ 1,133,335.74		22.5	38.0	$ 703,763.64	18.4	$ 71,459.21
Arizona	807,982.36	179,423.43	177,982.55		4.0	300,059.89	300,059.89		33.0	7.3	284,883.32	2.0	45,056.60
Arkansas	1,889,534.00	267,409.01	239,810.94	$ 27,598.07	7.0	1,112,223.25	1,058,589.04	$ 53,384.21	39.2	28.4	487,403.12	5.8	103,730.90
California	4,213,986.00	1,201,380.99	1,077,458.87		13.8	2,800,607.08	2,505,943.04		23.9	35.6	586,972.69	3.6	43,611.40
Colorado	1,718,633.00	890,911.16	845,103.51		17.2	651,210.04	651,210.04		24.1	13.4	150,989.02	3.6	71,330.43
Connecticut	802,407.00	48,325.68	48,325.68		.5	687,857.65	684,715.77	3,141.88	83.9	9.2	68,293.81	.5	1,071.74
Delaware	454,772.00	82,851.95	75,106.31		.8	203,298.40	203,298.40		49.8	1.9	139,750.00	4.9	36,617.29
Florida	1,307,959.00	238,246.83	178,494.68	59,752.15	3.6	1,307,477.38	1,129,464.32	178,013.06	47.0	13.8			
Georgia	2,724,620.00	270,623.84	270,623.84		12.4	1,047,709.04	1,047,709.04		38.1	35.3	250,709.42	11.9	1,155,577.70
Idaho	1,197,829.00	191,286.86	187,894.42		4.8	965,953.20	943,374.52		26.5	13.5			66,560.06
Illinois	7,718,839.00	213,649.45	213,618.50		3.7	6,298,412.04	6,298,412.04		54.4	64.2	1,033,873.00	3.0	172,935.46
Indiana	4,416,651.00	49,616.53	49,616.53		1.2	2,548,474.57	2,548,474.57		16.7	49.5	1,419,950.27	19.3	398,609.63
Iowa	2,815,585.00	703,618.21	667,865.00		23.6	1,319,843.17	1,247,030.00		56.0	21.6	254,524.50	5.6	646,165.50
Kansas	2,522,401.00	727,167.34	723,495.87		18.5	1,930,602.57	1,785,748.77		75.6	18.7	13,156.36	.1	
Kentucky	2,029,687.00	128,112.17	128,112.17		3.2	731,168.11	724,814.00		40.8	17.3	460,899.41	9.6	715,861.42
Louisiana	1,457,148.00	329,889.35	329,889.35		6.5	617,871.43	617,871.43		24.9	17.8	509,387.22	2.8	
Maine	909,878.00	162,188.29	161,062.72		2.4	646,816.12	645,444.82		48.1	13.9	24,448.68	.4	78,921.78
Maryland	891,132.00					390,738.31	386,588.31		15.5	3.6			504,543.69
Massachusetts	5,007,199.00	96,850.68	73,850.68	23,000.00	1.8	4,475,346.95	4,436,270.79	39,076.16	31.3	13.7	250,293.28	1.0	246,784.25
Michigan	3,438,781.00	195,700.00	195,700.00		2.3	2,722,745.00	2,720,995.00		39.2	35.2	414,075.00	3.5	108,411.00
Minnesota	3,719,143.00	956,049.40	955,888.64		53.6	1,880,914.07	1,869,617.18	2,500.00	20.3	41.9	291,480.62	4.8	602,156.36
Mississippi	1,744,669.00	122,848.45	110,388.95	12,459.50	3.8	638,526.86	638,526.86		27.2	25.4	302,596.74	7.1	693,156.45
Missouri	4,019,501.00	559,179.26	533,233.11		12.7	2,946,033.18	2,542,530.91		44.9	38.8	329,298.82	6.0	614,438.16
Montana	1,115,962.00	345,305.18	345,305.18		9.2	585,139.71	585,139.71		8.2	17.0	178,482.37	9.1	7,034.74
Nebraska	1,957,240.00	269,117.63	268,428.34		11.7	1,569,767.55	1,569,767.55		63.2	20.1	98,955.75	1.5	20,088.36
Nevada	500,051.00	47,203.38	47,203.38		1.2	411,763.76	411,763.76		9.5	7.0			41,083.86
New Hampshire	706,640.00					678,365.95	664,365.95		70.3	15.6	42,274.05	.9	
New Jersey	3,190,118.00	94,073.38	94,073.38		2.1	2,846,861.99	2,792,728.99	30,000.00	43.5	19.9	41,442.01	.5	261,873.62
New Mexico	1,448,234.00	437,759.58	437,759.58		13.1	843,703.69	843,703.69		43.7	16.0	66,812.89	3.2	99,957.84
New York	8,449,487.00	259,723.17	259,341.87		4.0	8,006,217.60	7,489,785.00	39,000.00	47.3	57.7	32,800.00	.6	667,560.13
North Carolina	2,380,573.00	588,701.49	586,560.20	166.10	30.4	962,606.47	961,328.18		23.4	34.4	285,608.05	10.0	547,076.57
North Dakota	1,451,112.00	128,994.64	128,994.64		9.3	454,556.75	427,371.39	27,185.36	50.4	13.7	595,459.44	25.2	299,286.53
Ohio	4,335,686.00	495,616.80	455,579.08		9.4	4,109,684.43	3,625,318.43		60.2	47.2	248,288.37	2.7	6,500.12
Oklahoma	2,304,200.00	220,928.88	220,571.20		7.9	1,664,345.07	1,664,345.07		48.4	32.0	196,978.40	4.5	222,305.33
Oregon	1,526,724.00	422,188.01	406,695.04	14,126.97	9.8	874,529.63	863,369.98		28.2	14.6	145,261.52	3.3	111,397.46
Pennsylvania	4,854,988.00	778,975.47	761,814.18		16.9	2,963,101.24	2,905,023.58		48.0	35.8	598,476.07	6.2	589,674.17
Rhode Island	499,677.00	54,063.40	54,063.40		1.2	338,974.92	338,974.92		54.9	5.2	106,638.68	1.0	
South Carolina	1,364,791.00	147,768.44	147,768.44		4.1	725,672.31	725,267.30	405.01	31.6	30.2	251,062.11	7.8	240,693.15
South Dakota	1,502,870.00	183,149.74	183,149.74		8.1	680,060.88	680,060.88		34.9	21.9	280,530.04	9.0	359,129.34
Tennessee	2,123,155.00	307,829.45	307,829.45		6.7	1,140,039.95	1,140,039.95		44.6	14.3	415,580.88	4.8	259,704.72
Texas	6,061,006.00	1,605,904.15	1,523,073.09		56.4	3,146,496.84	3,079,890.27		22.0	49.4	609,566.77	9.0	848,475.87
Utah	771,826.00	619,858.49	603,798.90		13.9	54,015.64	53,422.98		35.8	2.8			114,604.12
Vermont	500,509.00	41,791.73	41,791.73		1.9	455,811.48	433,717.27	5,838.96	40.6	12.0	25,000.00	.7	
Virginia	2,008,458.00	402,536.67	381,276.18	8,760.49	10.9	1,330,699.04	1,142,139.89		33.5	12.1	338,503.96	5.0	146,537.97
Washington	1,977,260.00	1,187,895.49	1,173,567.02		20.7	786,454.90	786,454.90		22.0	11.7			17,238.08
West Virginia	1,342,270.00	87,291.15	87,291.15		1.9	950,313.53	925,967.79		48.2	16.2	187,844.31	2.2	141,166.75
Wisconsin	2,684,067.00	399,615.60	393,308.77		13.5	1,870,171.39	1,834,767.78	25,898.24	46.4	35.2	259,388.07	3.1	196,602.38
Wyoming	1,125,332.00	82,029.39	81,528.69		1.6	922,428.60	885,471.78		50.8	18.3	45,380.40	3.2	112,951.13
District of Columbia	959,235.00	289,445.89	289,445.89		2.4	680,633.97	663,650.15		64.0	2.3			6,138.96
Hawaii													
TOTALS	115,042,340.36	17,297,070.49	16,707,715.45	145,863.28	468.8	76,409,641.34	73,613,461.62	404,442.88	41.8	1,120.6	13,027,083.06	227.4	11,694,080.23

CURRENT STATUS OF U.S. PUBLIC WORKS ROAD CONSTRUCTION
AS PROVIDED IN TITLE II, SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT

CLASS III—PROJECTS ON SECONDARY OR FEEDER ROADS

AS OF JUNE 30, 1934

STATE	PUBLIC WORKS FUNDS ASSIGNED FOR CLASS III PROJECTS ON SECONDARY HIGHWAYS	COMPLETED			UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION		BALANCE OF PUBLIC WORKS FUNDS AVAILABLE FOR NEW CLASS III PROJECTS	STATE
		Total cost	Public works funds	Mileage	Estimated total cost	Public works funds allotted	Percentage completed	Mileage	Public works funds allotted	Mileage		
Alabama	$2,092,533.00	$26,236.82	$26,236.82	.1	$857,518.34	$857,518.34	12.8	59.7	$960,759.52	83.0	$248,018.32	Alabama
Arizona	525,422.53	90,857.40	90,857.40	6.3	441,468.95	429,341.96	44.5	36.0			5,223.17	Arizona
Arkansas	1,484,634.00	41,727.43	41,727.43	15.9	948,842.90	948,842.90	34.9	118.9	135,002.66	9.3	359,061.01	Arkansas
California	3,589,691.00	617,476.51	497,034.19	16.0	3,204,357.74	2,721,574.10	33.7	154.9	151,579.17	6.7	219,503.54	California
Colorado	1,718,632.00	617,189.08	616,485.80	82.2	1,025,898.66	994,429.71	73.5	94.0	80,000.00	3.4	27,716.49	Colorado
Connecticut	659,120.00				664,915.58	659,120.00	27.8	14.5				Connecticut
Delaware	454,772.00				181,790.00	181,790.00	41.8	1.8	72,547.50	12.2	200,434.50	Delaware
Florida	1,307,958.00	397,589.58	397,589.58	26.0	850,256.61	850,256.61	65.9	45.6	28,423.34	3.6	31,688.17	Florida
Georgia	2,320,973.00	69,600.63	69,600.63	4.2	920,605.43	920,605.43	49.6	77.3	277,397.03	25.2	1,053,369.91	Georgia
Idaho	1,121,562.00	650,200.91	588,778.89	70.8	546,438.63	532,783.11	55.9	71.1				Idaho
Illinois	5,265,960.00	276,114.65	276,114.65	42.0	4,610,167.64	4,610,167.64	42.2	268.3	379,677.71	10.3		Illinois
Indiana	602,271.00				540,734.86	540,734.86	46.2	69.2			61,536.14	Indiana
Iowa	2,212,245.00	238,660.03	229,800.00	49.2	1,821,511.10	1,640,950.00	54.5	214.0	341,495.00	58.9		Iowa
Kansas	2,522,401.00	345,683.96	345,683.96	17.2	2,182,166.63	2,170,276.56	54.9	146.6	6,440.48	1.7		Kansas
Kentucky	1,879,340.00	448,942.86	448,876.03	69.0	1,391,976.64	1,390,591.40	66.0	146.5	30,000.00	5.4	9,872.57	Kentucky
Louisiana	1,457,148.00	73,405.37	73,405.37	2.4	922,070.51	922,070.51	24.9	42.9	286,879.00	11.5	174,793.12	Louisiana
Maine	842,479.00	577,668.36	571,325.97	54.5	347,893.22	261,598.53	95.0	27.4			9,554.50	Maine
Maryland	891,132.00	22,217.70	22,217.70	1.9	577,528.60	563,602.60	64.5	44.0	262,345.90	17.0	42,965.80	Maryland
Massachusetts	488,185.00				469,741.41	469,741.41	75.1	15.2			18,443.59	Massachusetts
Michigan	3,184,057.00	88,500.00	88,500.00	7.3	2,798,900.00	2,798,900.00	37.7	218.3	182,300.00	2.7	114,357.00	Michigan
Minnesota	2,376,415.00	573,461.23	561,616.55	81.8	1,619,796.48	1,613,476.33	46.4	190.1	5,000.00	1.5	196,322.12	Minnesota
Mississippi	1,744,669.00				801,275.41	801,275.41	42.6	92.4	445,874.39	40.0	497,519.20	Mississippi
Missouri	2,923,273.00	504,000.61	504,000.61	141.8	2,307,941.20	2,307,941.20	77.0	353.6	49,901.33	5.1	61,429.86	Missouri
Montana	1,859,937.00	712,695.05	712,695.05	97.6	1,119,834.58	1,119,834.58	20.5	125.0	26,572.33	3.5	835.04	Montana
Nebraska	1,957,240.00	213,260.07	213,260.07	70.3	1,834,682.07	1,728,953.58	64.8	213.3	12,325.86	.1	2,700.49	Nebraska
Nevada	1,136,479.00	700,561.17	700,561.17	70.6	307,468.71	307,468.71	38.1	28.2			128,449.12	Nevada
New Hampshire	477,460.00	82,647.15	82,647.15	2.5	435,560.52	394,736.67	76.5	23.2			76.18	New Hampshire
New Jersey	56,550.52				56,550.52	56,550.52	80.7	.5				New Jersey
New Mexico	1,448,234.00	351,481.58	351,481.58	62.1	874,633.59	874,633.59	58.3	240.3	20,000.00	3.0	202,118.83	New Mexico
New York	3,608,768.00	333,721.33	333,721.33	11.8	3,702,200.00	3,264,550.00	52.2	87.8			10,496.67	New York
North Carolina	2,380,573.00	690,265.25	689,866.92	51.2	1,119,390.77	1,081,106.83	36.1	186.2	80,200.00	15.1	529,399.25	North Carolina
North Dakota	1,451,112.00	6,021.51	6,021.51	1.4	176,701.59	176,701.59	33.3	22.5	545,234.59	165.0	723,154.31	North Dakota
Ohio	3,871,148.00	610,460.00	610,460.00	159.9	3,316,490.00	3,016,818.00	88.3	142.5	193,150.00	2.5	50,720.00	Ohio
Oklahoma	2,304,199.00	31,741.28	31,741.28	2.9	1,783,376.08	1,677,379.13	24.3	194.4	567,265.51	73.8	27,813.08	Oklahoma
Oregon	1,526,724.00	541,068.81	502,843.61	41.7	1,050,254.52	928,020.15	34.3	55.7	95,860.24	11.1		Oregon
Pennsylvania	7,344,822.00	258,906.83	258,906.83	30.0	6,821,281.19	6,735,617.79	49.7	605.3	252,768.17	20.7	97,529.21	Pennsylvania
Rhode Island	499,677.00				412,465.02	412,465.02	57.0	33.2			87,211.98	Rhode Island
South Carolina	1,364,791.00	54,313.20	54,313.20	1.6	1,247,341.80	1,247,341.80	54.9	144.0	63,136.00	8.7		South Carolina
South Dakota	1,502,870.00	183,741.74	183,741.74	73.2	427,523.09	427,523.09	36.2	140.4	410,634.58	153.1	480,970.59	South Dakota
Tennessee	2,123,155.00	342,701.04	342,701.04	29.3	955,167.96	955,167.96	54.0	74.3	636,341.23	48.8	188,944.77	Tennessee
Texas	6,061,006.00	2,385,381.53	1,835,753.10	408.9	3,984,158.53	3,667,285.48	48.4	366.8	117,416.66	2.5	440,550.76	Texas
Utah	1,048,677.00	523,984.51	504,437.24	107.3	470,666.59	445,300.00	55.7	51.3	68,967.69	5.9	29,972.07	Utah
Vermont	438,880.00				444,002.49	424,132.63	38.0	36.0	14,747.37	.4		Vermont
Virginia	1,699,920.00	518,382.22	498,897.89	96.9	1,054,220.53	993,814.18	54.4	108.5	160,251.99	1.0	46,955.94	Virginia
Washington	1,080,673.00	403,092.71	393,092.71	27.6	653,151.30	653,151.30	31.4	36.1	27,739.30	3.9	6,689.69	Washington
West Virginia	1,118,559.00	21,945.79	21,945.79	.7	897,576.45	897,576.45	42.0	50.0	127,232.93	9.2	71,803.83	West Virginia
Wisconsin	2,425,385.00	894,060.15	858,749.84	58.8	1,333,491.78	1,288,586.71	26.2	95.3	148,404.19	16.6	129,644.26	Wisconsin
Wyoming	1,125,332.00	465,442.38	454,233.00	56.6	626,347.56	611,181.00	45.2	91.6	59,918.00	9.6		Wyoming
District of Columbia	959,234.00	208,113.99	208,113.99	2.6	750,914.71	750,914.71	40.2	5.2			205.30	District of Columbia
Hawaii	187,106.00				177,717.69	177,717.69	32.0	4.9			9,388.31	Hawaii
TOTALS	92,723,384.05	16,193,522.72	15,300,037.92	2,154.1	66,066,966.18	63,502,117.77	49.2	5,604.8	7,323,789.67	852.0	6,597,438.69	TOTALS

PUBLICATIONS of the BUREAU OF PUBLIC ROADS

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. As his office is not connected with the Department and as the Department does not sell publications, please send no remittance to the United States Department of Agriculture.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1924. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1927. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1928. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1929. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1932. 10 cents.

DEPARTMENT BULLETINS

No. 136D . . Highway Bonds. 20 cents.

No. 347D . . Methods for the Determination of the Physical Properties of Road-Building Rock. 10 cents.

No. 532D . . The Expansion and Contraction of Concrete and Concrete Roads. 10 cents.

No. 583D . . Reports on Experimental Convict Road Camp, Fulton County, Ga. 25 cents.

No. 660D . . Highway Cost Keeping. 10 cents.

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922. 15 cents.

TECHNICAL BULLETINS

No. 55T . . Highway Bridge Surveys. 20 cents.

No. 265T . . Electrical Equipment on Movable Bridges. 35 cents.

MISCELLANEOUS CIRCULARS

No. 62MC . . Standards Governing Plans, Specifications, Contract Forms, and Estimates for Federal-Aid Highway Projects. 5 cents.

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No. 76MP . . The results of Physical Tests of Road-Building Rock. 25 cents.

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REPRINT FROM PUBLIC ROADS

Reports on Subgrade Soil Studies. 40 cents.

Single copies of the following publications may be obtained from the Bureau of Public Roads upon request. They cannot be purchased from the Superintendent of Documents.

SEPARATE REPRINT FROM THE YEARBOOK

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regiona Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

A complete list of the publications of the Bureau of Public Roads, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to the U.S. Bureau of Public Roads, Willard Building, Washington, D.C.

CURRENT STATUS OF U.S. PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED IN TITLE II, SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT

SUMMARY OF CLASSES I, II, AND III

AS OF JUNE 30, 1934

STATE	TOTAL APPORTIONMENT OF PUBLIC WORKS FUNDS	COMPLETED				UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION		BALANCE OF PUBLIC WORKS FUNDS AVAILABLE FOR ALL NEW PROJECTS
		Total cost	Public works funds	Regular Federal aid	Mileage	Estimated total cost	Public works funds allotted	Regular Federal aid allotted	Percentage completed	Mileage	Public works funds allotted	Mileage	
Alabama	$ 8,370,133	$ 1,806,652.38	$ 1,090,782.86	$ 715,869.52	65.1	$ 6,616,632.75	$ 4,579,589.21	$ 2,037,043.54	33.1	370.0	$ 1,898,471.75	122.9	$ 801,289.18
Arizona	5,211,960	2,046,484.71	2,004,382.65		141.4	3,339,932.74	2,746,710.97		51.9	196.5	381,624.30	12.7	79,242.08
Arkansas	6,748,335	609,101.26	481,665.31	127,435.95	32.4	4,782,355.25	4,336,045.66	445,578.34	49.0	284.3	1,258,915.07	39.1	671,708.96
California	15,607,354	5,656,013.18	4,528,869.81		172.3	12,089,450.96	9,875,918.69		54.0	343.6	930,345.26	26.2	272,220.24
Colorado	6,874,530	3,022,131.93	2,962,379.61		195.4	3,737,033.79	3,571,936.47	27,435.65	54.1	162.3	230,989.02	7.0	109,224.90
Connecticut	2,865,740	80,124.44	80,124.44		.6	2,896,535.89	2,711,818.89	178,920.82	45.9	54.4	68,293.81	.5	5,502.86
Delaware	1,819,088	274,915.09	266,277.02		3.8	1,083,829.70	1,083,829.70		57.5	18.4	218,067.50	17.4	250,913.78
Florida	5,231,834	1,916,897.59	1,390,159.38	526,738.21	73.3	4,097,779.72	3,583,473.43	513,696.19	59.1	131.7	84,705.09	4.3	173,496.10
Georgia	10,091,185	1,572,745.52	1,572,745.52		90.2	4,368,602.28	4,368,602.28		42.4	290.1	1,045,325.29	59.5	3,104,511.91
Idaho	4,486,249	1,666,092.63	1,586,453.50		157.4	2,793,637.80	2,715,549.72		42.0	178.1	13,782.82		170,462.96
Illinois	17,570,770	540,636.64	540,605.69		46.6	13,621,077.74	13,621,077.74		48.0	377.6	3,176,243.20	26.6	232,843.37
Indiana	10,037,843	49,616.53	49,616.53		1.2	7,494,686.64	7,450,567.81		31.6	238.2	2,077,512.89	38.5	460,145.77
Iowa	10,055,660	1,999,978.66	1,936,465.00		147.3	7,267,687.25	6,716,960.00		66.7	421.2	736,695.00	73.5	665,540.00
Kansas	10,089,604	2,403,085.86	2,398,545.41		242.2	8,030,154.68	7,646,070.45		71.1	356.4	64,988.14	2.1	
Kentucky	7,517,359	1,131,158.04	1,126,634.92		131.8	4,722,349.06	4,705,771.28		63.9	341.7	959,218.81	31.5	725,733.99
Louisiana	5,828,591	625,710.21	625,685.21		18.6	4,453,210.60	3,946,559.60		38.5	128.2	838,890.20	15.8	417,455.99
Maine	3,369,917	739,856.65	732,388.69		56.9	2,509,937.71	2,386,704.77		58.5	85.3	48,534.12	.6	202,289.42
Maryland	3,564,527	22,217.70	22,217.70		1.9	1,769,410.69	1,741,685.94		46.4	62.5	724,195.90	23.4	1,076,427.46
Massachusetts	6,597,100	386,424.52	286,228.62	92,984.24	8.2	6,068,458.12	5,713,722.32	354,735.80	39.6	60.3	250,293.28	1.0	346,855.78
Michigan	12,736,227	364,350.00	364,350.00		11.4	10,698,825.00	10,647,675.00	49,000.00	43.1	497.3	1,198,741.00	27.2	525,461.00
Minnesota	10,656,569	4,018,218.36	3,985,730.25	20,482.87	644.9	5,481,281.76	5,432,453.84	30,000.00	32.0	469.7	439,906.43	19.0	798,478.48
Mississippi	6,978,675	411,372.98	274,599.14	136,773.84	16.6	6,026,784.62	3,921,151.83	2,067,000.85	43.5	353.0	1,024,541.35	76.2	1,758,382.68
Missouri	12,180,306	1,958,601.48	1,732,331.58		198.0	9,644,757.95	8,901,113.11	68,548.60	65.2	542.0	631,233.65	20.4	915,627.66
Montana	7,439,748	2,484,917.43	2,304,901.43	100,000.00	200.2	5,246,316.95	4,886,660.15	237,025.83	43.3	412.5	237,042.81	48.8	11,143.61
Nebraska	7,828,961	2,605,201.12	2,016,707.53	108,538.00	297.8	6,366,062.53	5,641,588.82		63.5	370.5	147,076.19	11.3	23,588.46
Nevada	4,545,917	2,097,159.73	2,097,159.73		244.8	2,120,252.90	2,120,252.90		28.6	122.3	79,129.02		249,375.35
New Hampshire	1,909,839	134,671.58	134,671.58		2.8	1,715,129.51	1,653,798.25		75.8	49.3	42,274.05	.9	79,095.12
New Jersey	6,346,039	160,151.25	160,151.25		8.2	5,659,697.65	5,450,643.64	169,466.42	38.6	56.8	104,945.89	1.1	630,298.22
New Mexico	5,792,935	2,662,688.71	2,662,688.71		285.7	2,782,780.24	2,638,850.82	143,929.42	43.8	316.4	128,714.77	9.8	362,680.70
New York	22,330,101	1,103,667.14	1,003,225.84	43,000.00	23.8	22,989,026.28	20,415,058.68	354,000.00	51.4	375.5	179,797.80	9.0	732,018.68
North Carolina	9,522,293	2,316,265.85	1,990,948.67	322,943.66	185.1	5,392,834.10	4,999,941.10	353,330.77	39.3	625.7	859,624.03	78.0	1,671,779.20
North Dakota	5,804,448	1,185,568.32	1,182,236.34	3,294.32	468.6	2,145,185.02	1,919,321.79	225,863.23	46.5	440.8	1,613,983.73	328.4	1,088,906.14
Ohio	15,484,592	2,141,452.27	2,096,220.71		197.1	13,863,632.43	12,775,221.43	51,410.00	69.9	348.8	519,316.37	10.2	93,833.49
Oklahoma	9,216,798	1,491,881.34	1,489,920.12		112.2	6,379,056.84	6,273,059.89		55.3	422.7	911,212.35	81.4	542,605.64
Oregon	6,106,896	2,488,491.83	2,302,156.66	98,444.47	150.4	3,548,284.40	3,276,350.18	128,021.20	37.8	153.5	408,509.78	15.8	119,879.38
Pennsylvania	18,891,004	1,292,671.11	1,275,142.80		51.3	15,863,939.07	15,536,514.87		47.3	763.1	1,328,626.91	32.6	750,719.42
Rhode Island	1,998,708	104,241.40	104,241.40		2.3	1,688,559.28	1,688,559.28		62.8	57.8	115,371.04	1.0	90,536.28
South Carolina	5,459,165.	465,522.03	465,522.03		30.0	4,012,419.10	4,009,284.47	3,134.63	48.5	360.5	458,295.22	25.5	526,063.28
South Dakota	6,011,479	1,453,187.56	1,433,846.17	19,341.39	266.2	2,957,477.42	2,649,683.60	307,793.82	28.8	412.5	834,642.10	204.0	1,093,307.13
Tennessee	8,492,619	2,043,736.55	1,830,674.25	213,062.30	97.5	5,009,525.75	4,648,365.56	361,160.19	51.9	192.6	1,442,646.74	77.8	570,932.45
Texas	24,244,024	8,173,921.58	6,863,517.31		1,007.7	14,546,596.99	13,624,462.13		40.3	873.7	1,055,547.40	37.7	2,700,496.56
Utah	4,194,708	2,575,936.17	2,537,560.60		267.2	1,322,833.39	1,296,874.14		57.2	102.9	137,171.79	6.3	223,101.47
Vermont	1,867,573	132,315.95	131,718.66		9.3	1,747,512.74	1,676,099.12	5,838.96	48.9	85.4	43,745.83	1.1	16,009.39
Virginia	7,416,757	2,022,430.39	1,972,211.54	18,234.52	148.0	4,500,288.02	4,128,116.07	119,858.30	48.5	202.0	886,111.73	29.8	430,317.66
Washington	6,115,867	2,475,339.20	2,446,222.83	3,356.82	93.0	3,535,412.21	3,535,412.21		33.1	108.7	92,379.97	5.3	41,851.99
West Virginia	4,474,234	320,707.27	320,707.27		9.3	3,554,123.66	3,523,777.92		58.6	131.1	349,106.66	12.1	280,642.15
Wisconsin	9,724,881	2,367,133.14	2,315,177.28	1,190.00	122.3	6,757,332.51	6,575,489.78	64,398.24	39.2	304.8	470,966.51	21.1	363,247.43
Wyoming	4,501,327	1,552,598.23	1,418,434.69	80,400.00	236.1	2,972,049.23	2,776,765.01	85,908.57	45.3	382.8	172,329.92	23.0	133,797.38
District of Columbia	1,918,469	497,559.88	497,559.88		5.0	1,431,548.68	1,414,564.86		51.4	7.5			6,344.26
Hawaii	1,871,062	122,232.70	109,225.57	12,994.32	6.3	1,803,971.40	1,502,765.58	251,205.82	28.0	31.4	248,693.76	6.8	10,377.09
TOTALS	394,000,000	79,774,036.09	73,201,990.29	2,645,084.43	6,985.7	283,506,260.40	263,042,470.96	8,634,305.19	48.5	13,674.4	31,148,776.25	1,718.2	26,606,762.50

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